

RECTANGULAR-BEAM ION SOURCE



Prepared for
LEWIS RESEARCH CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
P.O. C-37730-D

NASA-CR-159877
19830003989

NASA CR-159, 877

Suppl.

July 1980
Harold R. Kaufman
Department of Physics
Colorado State University
Ft. Collins, Colorado 80523

Library copy
SEP 2 1980
LIBRARY
HAMPTON, VIRGINIA
ER

12085

5018



FOREWORD

THIS PUBLICATION IS ASSOCIATED WITH NASA CONTRACTOR REPORT CR-159877, GENERATED UNDER NASA GRANT 3086, WITH MICHAEL J. MIRTICH, JR. THE GRANT MANAGER. THE THEORETICAL DESIGN AND PERFORMANCE OF THIS 5x40cm RECTANGULAR-BEAM ION SOURCE WAS COVERED IN CR-159877. THE ION SOURCE USED IN CR-159877 WAS A RESEARCH-GRADE DESIGN IN THAT EASE OF FABRICATION WAS CONSIDERED MORE IMPORTANT THAN RELIABILITY AND DURABILITY.

THE FABRICATION AND ASSEMBLY OF A COMMERCIAL-GRADE RECTANGULAR BEAM ION SOURCE IS COVERED HEREIN, WITH A MUCH GREATER EMPHASIS ON RELIABILITY AND DURABILITY. THE ELECTRICAL PERFORMANCE SHOULD BE QUITE SIMILAR TO THE RESEARCH-GRADE SOURCE, SO THAT CR-159877 CAN BE USED AS A PERFORMANCE GUIDE. BOTH SOURCES WERE DESIGNED TO REJECT HEAT LOSSES BY RADIATION WITHIN A VACUUM SYSTEM. THIS APPROACH PERMITS THE GREATEST FLEXIBILITY WITH REGARD TO THE VACUUM SYSTEM.

1256L-18N

TABLE OF CONTENTS

PAGE

FOREWORD — — — — —	i
SPECIFICATIONS — — — — —	1
FABRICATION DRAWINGS — — — — —	2
ASSEMBLY DRAWINGS — — — — —	30
PARTS LIST — — — — —	40
MATERIALS LIST — — — — —	41
ASSEMBLY INSTRUCTIONS — — — — —	42

SPECIFICATIONS

BEAM SIZE: 5 X 40 cm

SOURCE SIZE: 15 X 17 X 46 cm

SOURCE MASS: ~7kg

ENVIRONMENT:

Designed to reject heat by radiation in vacuum environment

DESIGN PERFORMANCE:

Ion current density for 500-1500 eV,

$\leq 6 \text{ mA/cm}^2$ average at ion optics

$\leq 3 \text{ mA/cm}^2$ average at 10 cm from ion source

(Ar gas; total voltage, 2000; maximum half-angle, 12°)

EXPERIMENTAL PERFORMANCE

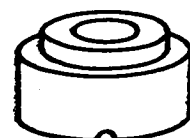
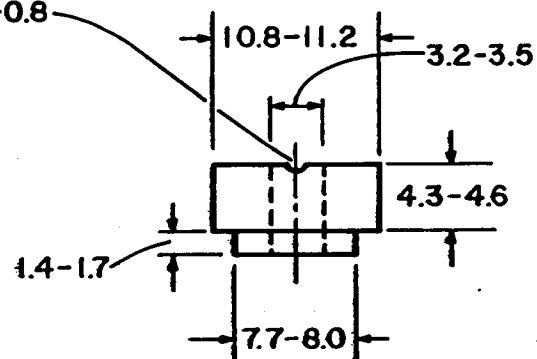
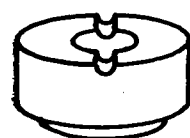
See NASA CR-159877

FABRICATION DRAWINGS

ALL DIMENSIONS IN mm UNLESS OTHERWISE NOTED.

ALL TOLERANCES ± 0.1 mm UNLESS OTHERWISE NOTED.

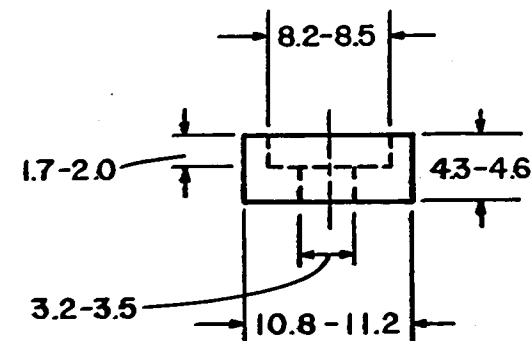
NOTCH DEPTH
AND RADIUS
0.5-0.8



INVERTED

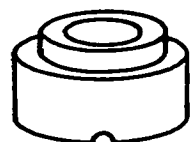
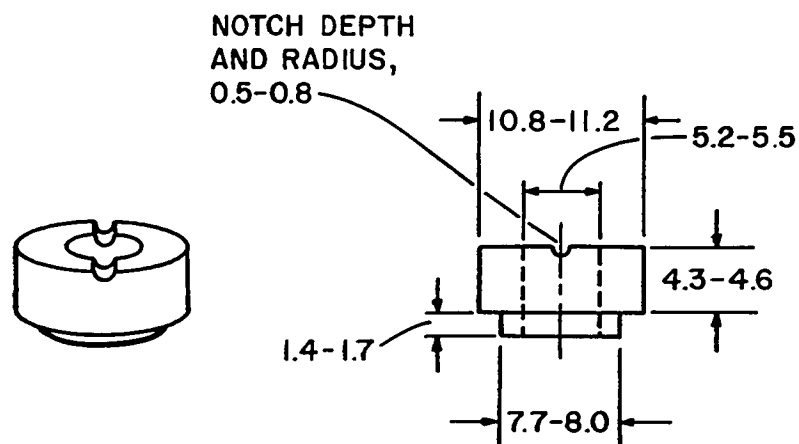
SEE GENERAL NOTES
FOR ALUMINUM OXIDE
PARTS (PAGE 6)

PART NO. 1
ANODE FEEDTHROUGH (M)
MAT'L: ALUMINUM OXIDE
SCALE: 2X



SEE GENERAL NOTES
FOR ALUMINUM OXIDE
PARTS (PAGE 6)

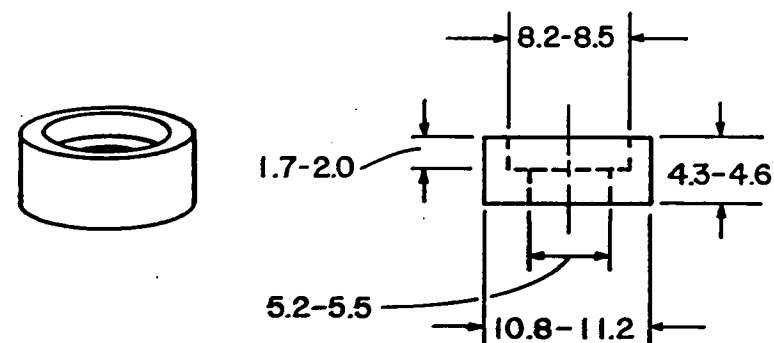
PART NO. 2
ANODE FEEDTHROUGH (F)
MAT'L: ALUMINUM OXIDE
SCALE: 2X



INVERTED

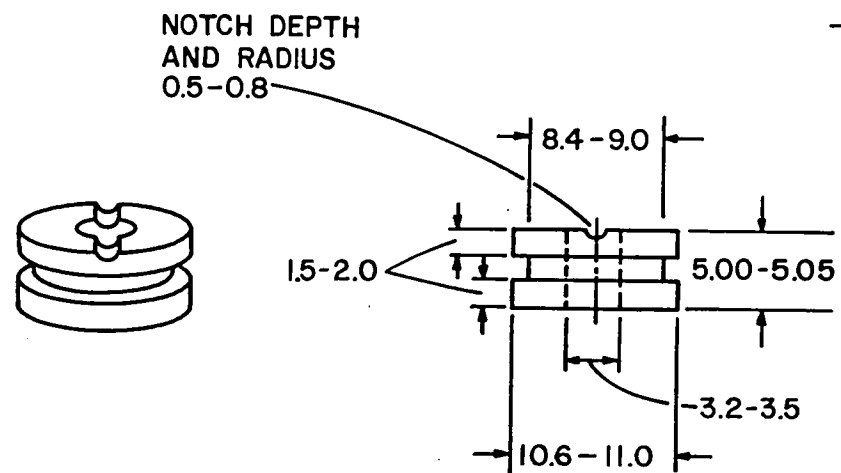
SEE GENERAL NOTES
FOR ALUMINUM OXIDE
PARTS (PAGE 6)

PART NO.3
CATHODE FEEDTHROUGH (M)
MAT'L : ALUMINUM OXIDE
SCALE : 2X



SEE GENERAL NOTES
FOR ALUMINUM OXIDE
PARTS (PAGE 6)

PART NO.4
CATHODE FEEDTHROUGH (F)
MAT'L : ALUMINUM OXIDE
SCALE : 2X

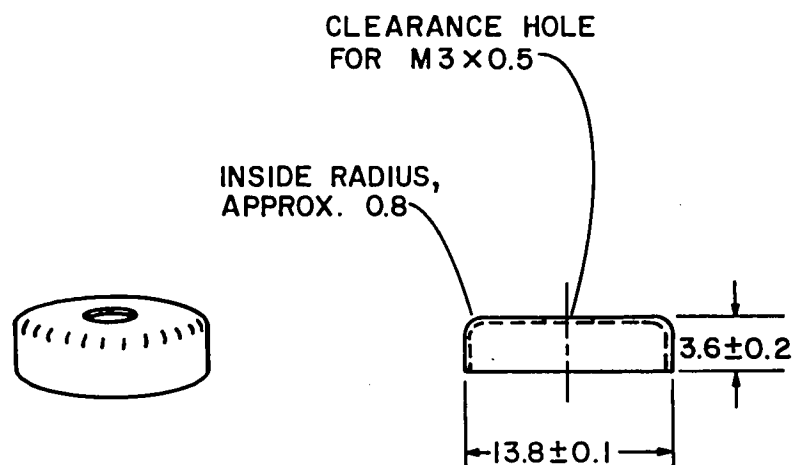


SEE GENERAL NOTES
FOR ALUMINUM OXIDE
PARTS (PAGE 6)

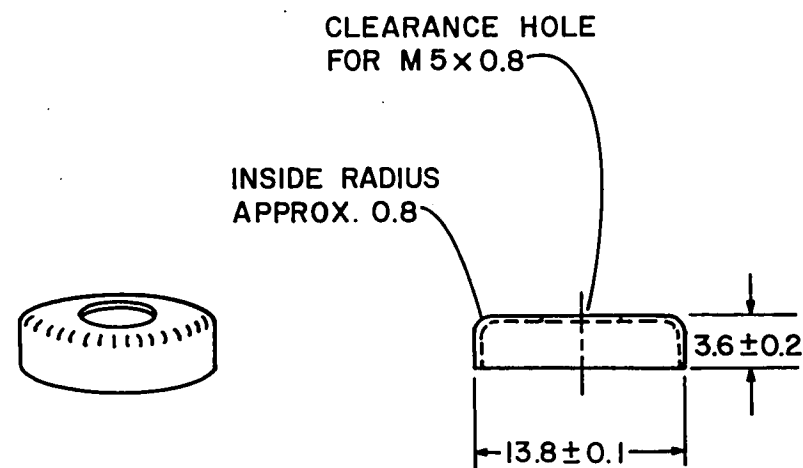
PART NO. 5
ION OPTICS INSULATOR
MAT'L : ALUMINUM OXIDE
SCALE : 2X

GENERAL NOTES FOR ALUMINUM OXIDE PARTS :

1. PURITY : 96%, OR MORE, Al_2O_3 .
2. BREAK ALL CORNERS TO APPROXIMATELY 0.3 RADIUS.
3. RUNOUT ON FLAT SURFACES, 0.05, OR LESS.
4. CYLINDRICAL SURFACES COAXIAL TO 0.13, OR LESS.
5. PART NO.1 SIMILAR TO PART NO.3 EXCEPT FOR HOLE DIAMETER AND PART NO.2 SIMILAR TO PART NO.4 EXCEPT FOR HOLE DIAMETER, TO MINIMIZE TOOLING REQUIRED.
6. ALL TOLERANCES (EXCEPT ONE) ARE SUFFICIENT TO PERMIT MACHINING WHEN "GREEN". (NO MACHINING AFTER FIRING.)
7. EXCEPTION TO ABOVE NOTE IS 5.00-5.05 DIMENSION OF PART NO.5, WHICH WILL REQUIRE FINISH GRINDING AFTER FIRING.



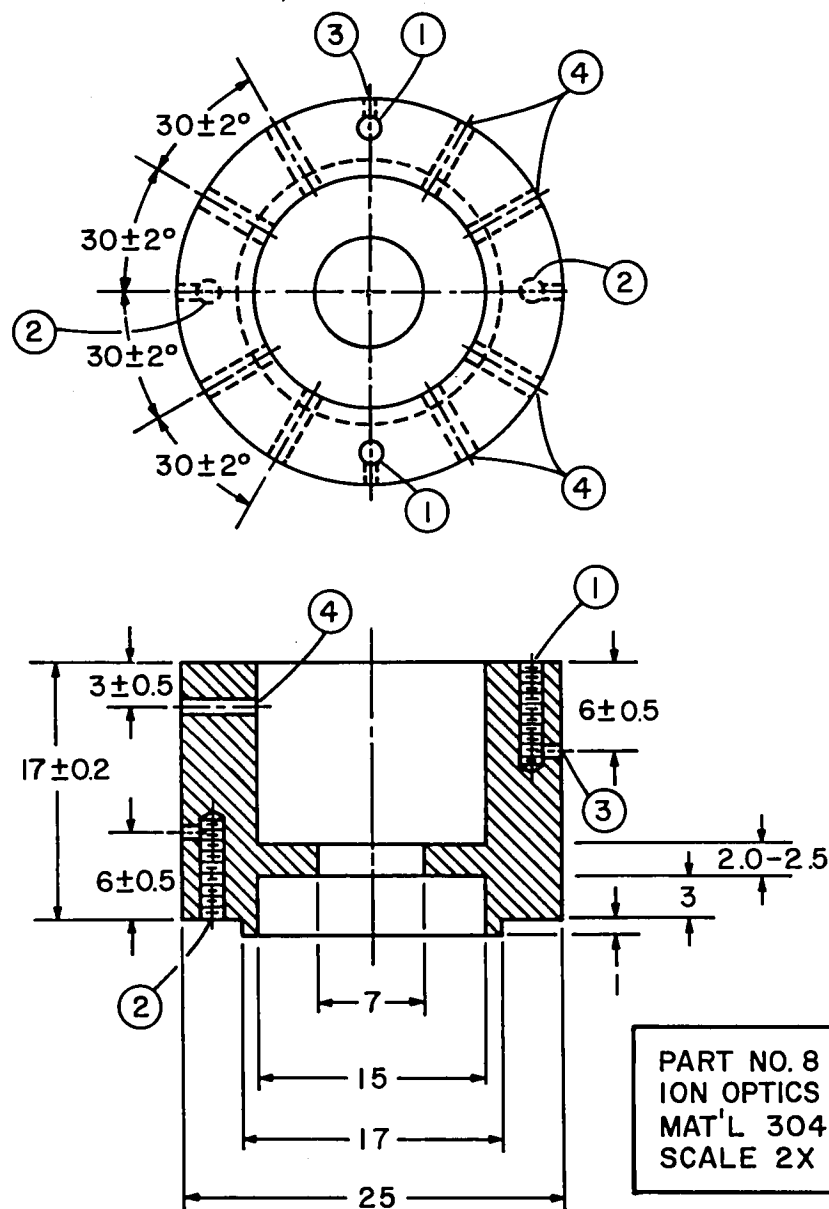
PART NO. 6
ANODE SPUTTER SHIELD
MAT'L : 304 S.S., 0.25 THICK
SCALE : 2X



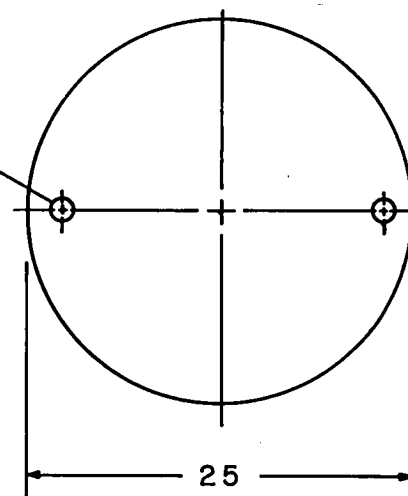
PART NO. 7
CATHODE SPUTTER SHIELD
MAT'L : 304 S.S., 0.25 THICK
SCALE : 2X

NOTES:

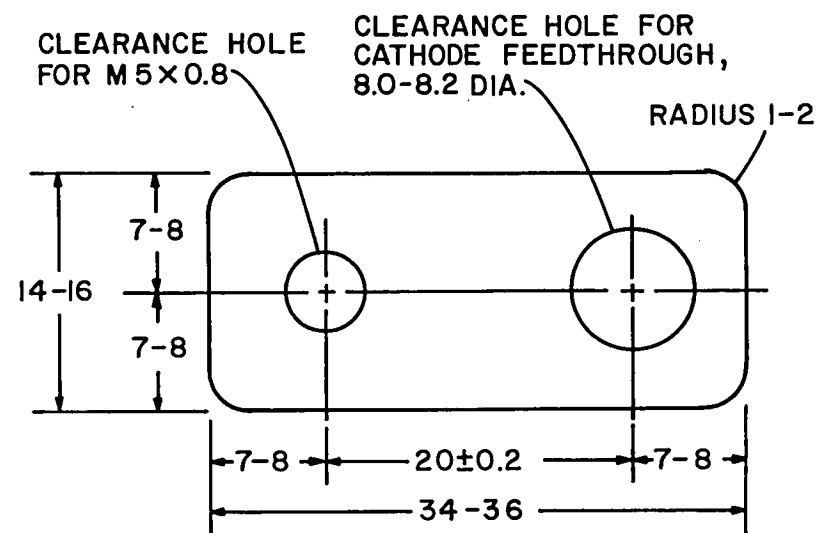
- ① TWO HOLES, DRILLED AND TAPPED FOR M1.6 X 0.35 THREADS, WITH USEFUL THREADS AT LEAST 4 DEEP. CIRCUMFERENTIAL LOCATIONS SHOWN IN TOP VIEW, ON 22 DIA CIRCLE.
- ② FOUR HOLES, DRILLED AND TAPPED FOR M1.6 X 0.35 THREADS, WITH USEFUL THREADS AT LEAST 4 DEEP. TWO CIRCUMFERENTIAL LOCATIONS SHOWN IN TOP VIEW, OTHER TWO HIDDEN BEHIND HOLES FOR NOTE ① IN TOP VIEW, ON 22 DIA CIRCLE.
- ③ OUTGASSING HOLES, 1 DIA, TO ALL DRILLED AND TAPPED HOLES. (6 IN ALL)
- ④ EIGHT OUTGASSING HOLES, 1 DIA, TO CENTER CAVITY.



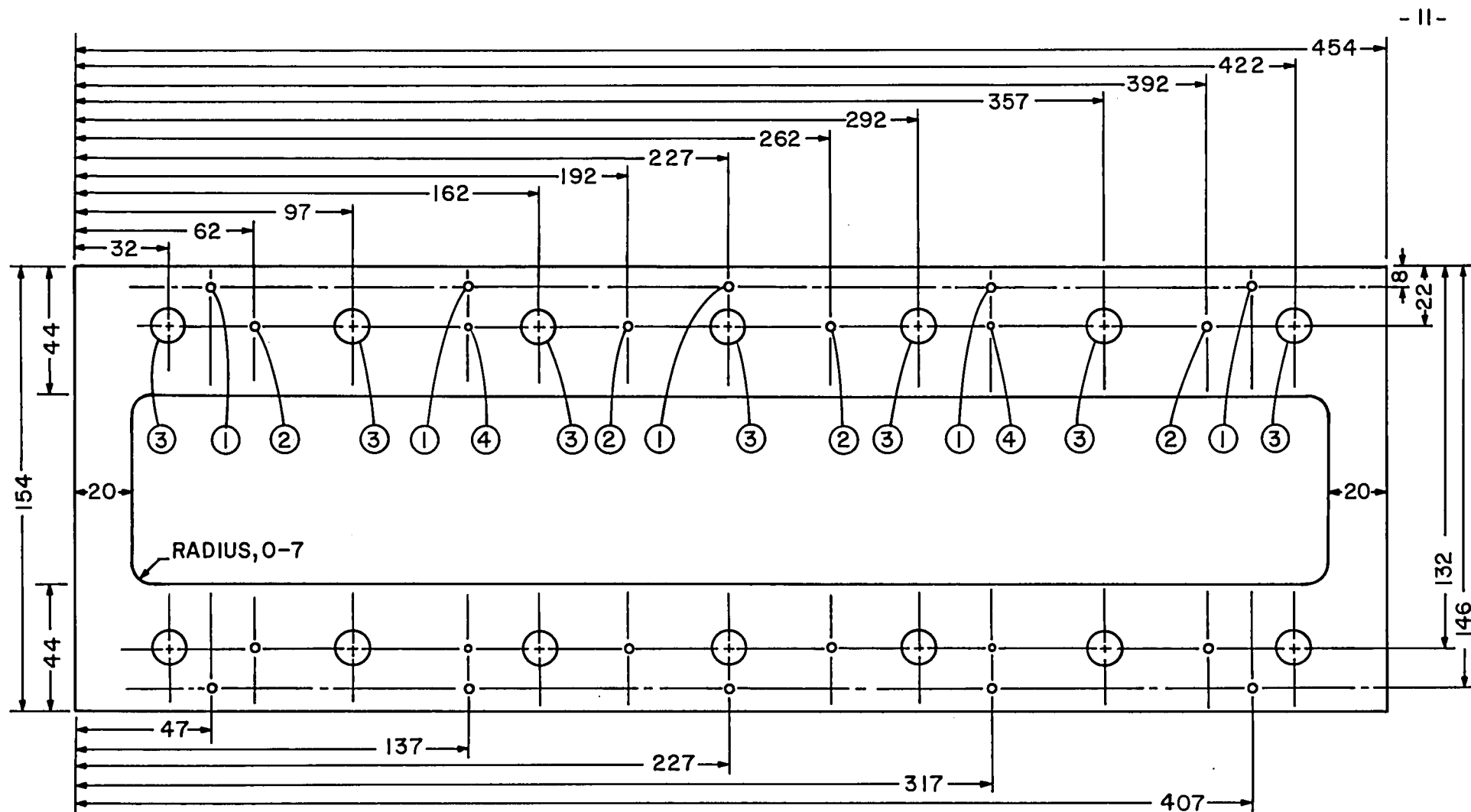
TWO CLEARANCE HOLES
FOR M1.6X0.35 SCREWS,
ON 21 DIA CIRCLE, 180°
APART.



PART NO. 9
ION OPTICS SUPPORT COVER
MAT'L: 304 S.S., 0.7-1.1 THICK
SCALE: 2 X



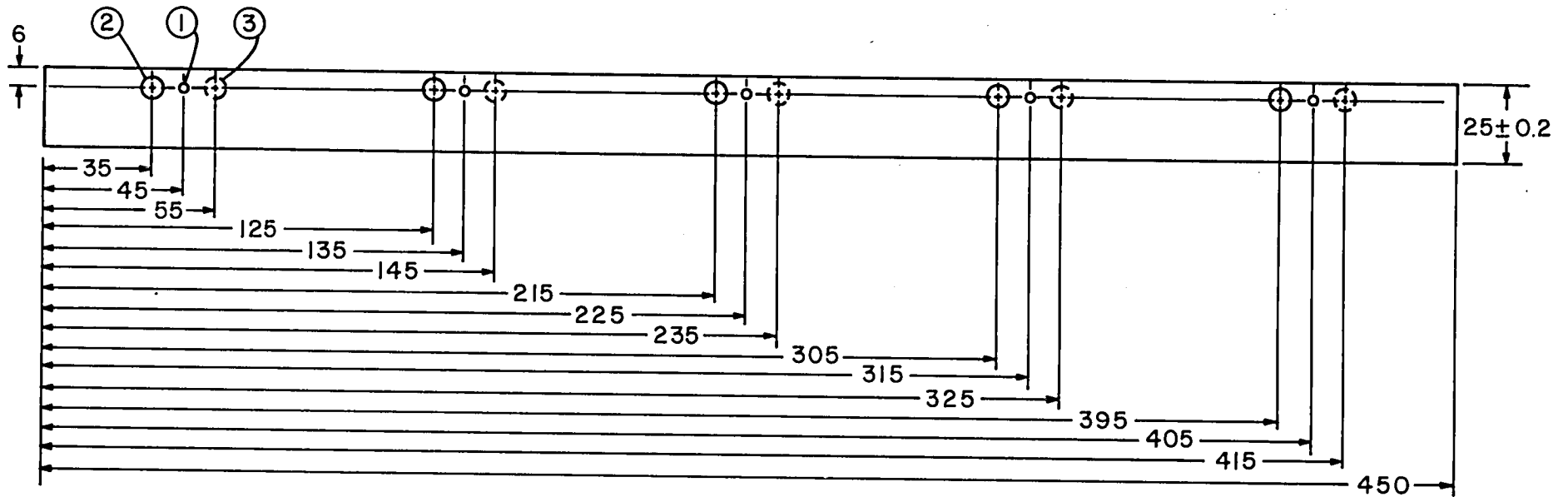
PART NO. 10
TORQUE PLATE
MAT'L: 304 S.S., 0.7-1.2 THICK
SCALE: 2X



NOTES:

- ① 10 HOLES, DRILLED AND TAPPED FOR M3×0.5
- ② 8 HOLES, DRILLED AND TAPPED FOR M3×0.5
- ③ 14 HOLES, 11-12 DIA.
- ④ 4 HOLES, 2 DIA.

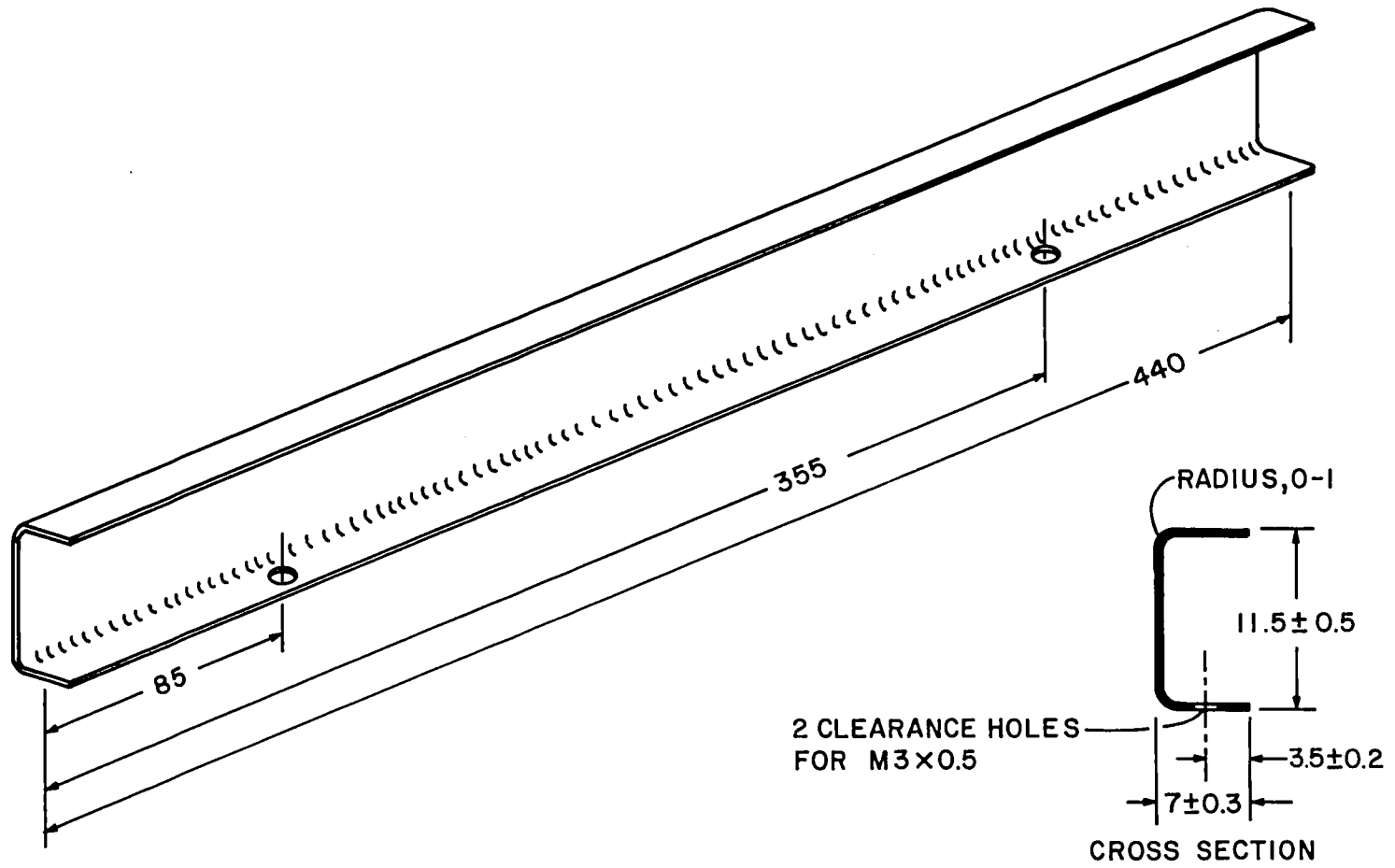
PART NO. 11
 MAIN FRAME
 MAT'L: 304 S.S., 4.0-4.5 THICK,
 FLAT WITHIN 0.5
 SCALE: 1/2



NOTES:

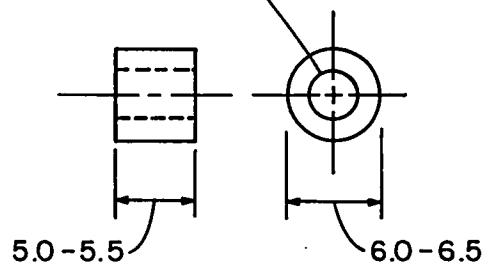
- ① 5 CLEARANCE HOLES FOR M3X0.5
- ② 5 END MILLED HOLES, 6.4 DIA, 1.0 DEEP, FROM TOP
- ③ 5 END MILLED HOLES, 6.4 DIA, 1.0 DEEP, FROM BOTTOM

PART NO. 12
MAGNETIC POLE PIECE
MAT'L: LOW CARBON STEEL OR
400 SERIES S.S., 1.5 THICK
SCALE: 1/2



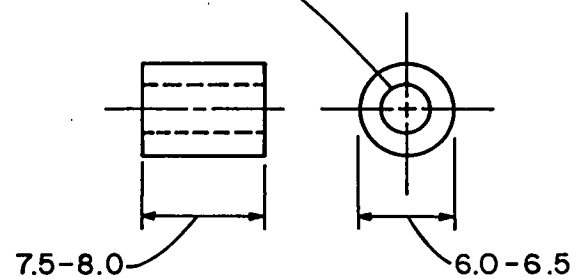
PART NO. 13
ANODE
MAT'L: 304 S.S., 0.5 THICK
NOT TO SCALE

CLEARANCE HOLE
FOR M3×0.5

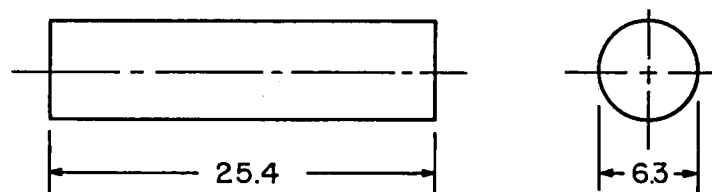


PART NO. 14
ANODE SPACER, SHORT
MAT'L: 304 S.S.
SCALE: 2X

CLEARANCE HOLE
FOR M3×0.5

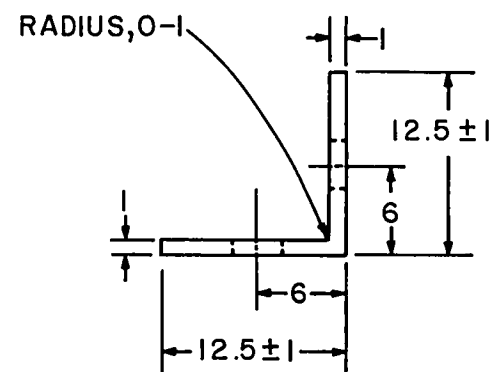
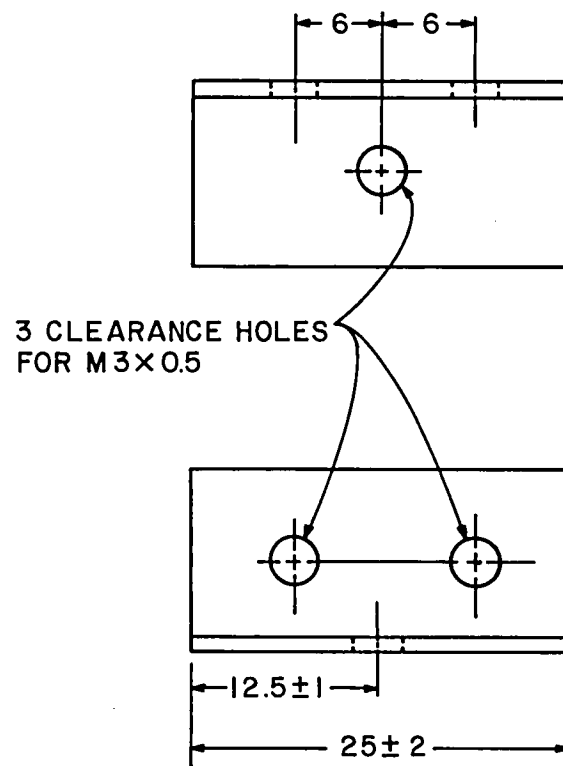


PART NO. 15
ANODE SPACER, LONG
MAT'L: 304 S.S.
SCALE: 2X

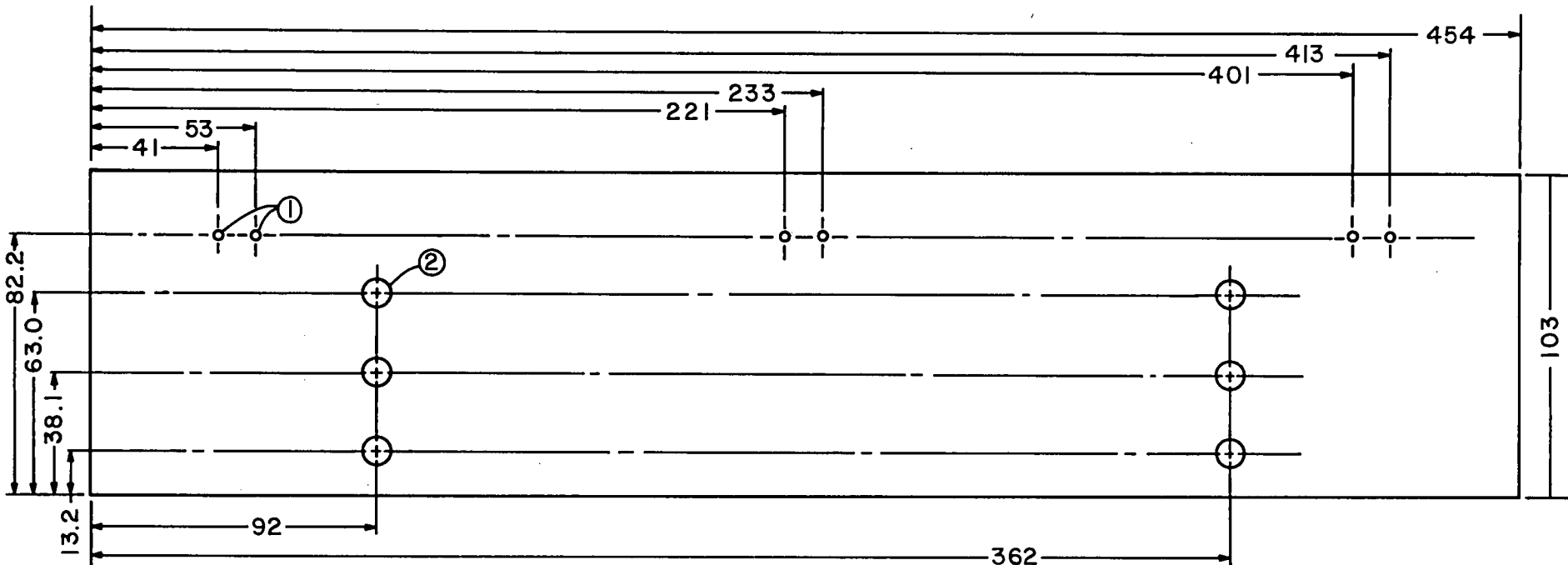


NOTE: 100% CLEANUP ON
CYLINDRICAL SURFACE

PART NO.16
MAGNET
MAT'L: ALNICO ∇
SCALE: 2X



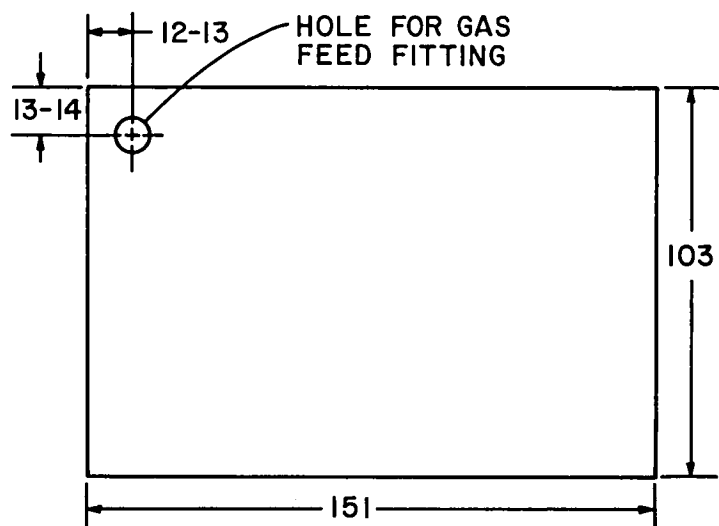
PART NO. 17
POLE PIECE BRACKET
MAT'L : 304 S.S.
SCALE: 2X



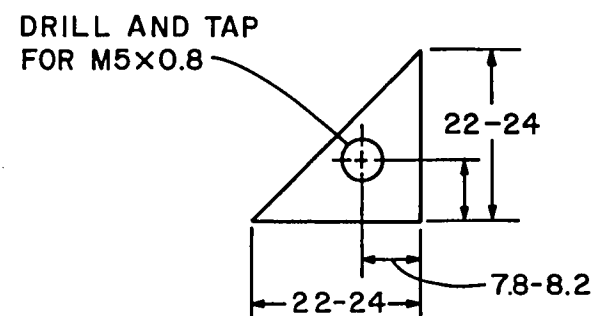
NOTES :

- ① 6 CLEARANCE HOLES FOR M3X0.5, FOR POLE PIECE CLAMPS
② 6 CLEARANCE HOLES FOR ANODE FEEDTHROUGHS, 8.0-8.2 DIA

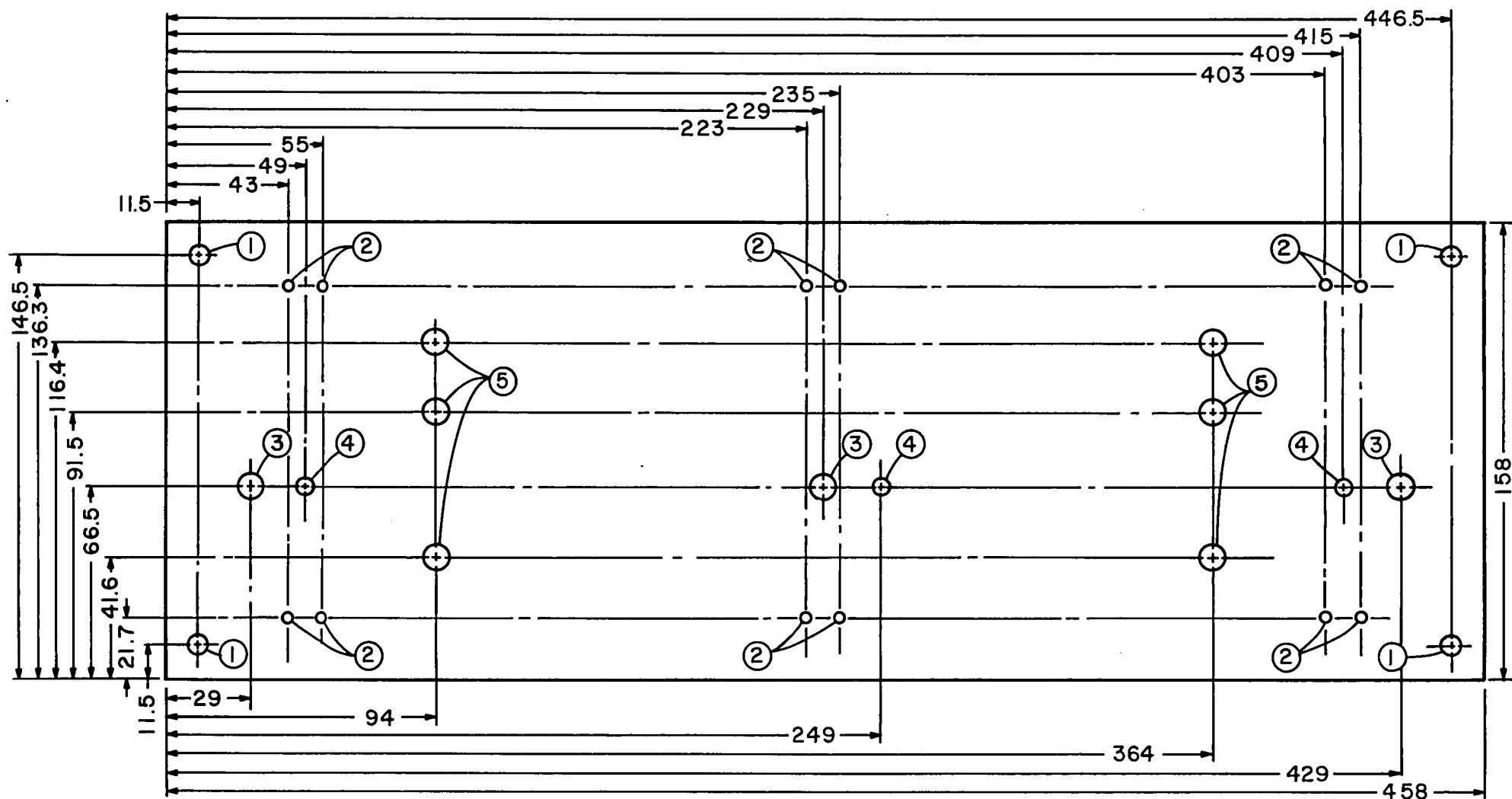
PART NO. 18
CHAMBER SIDE WALL
MAT'L : 304 S.S., 1.5 THICK
SCALE : 1/2



PART NO. 19
CHAMBER END WALL
MAT'L: 304 S.S., 1.5 THICK
SCALE: 1/2



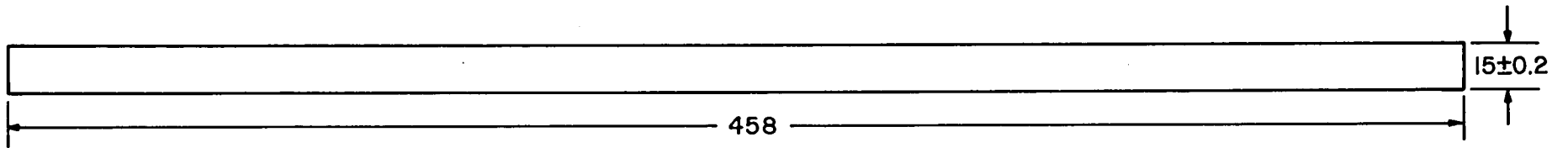
PART NO. 20
CHAMBER CORNER BRACKET
MAT'L: 304 S.S., 3-4.5 THICK
SCALE: FULL SIZE



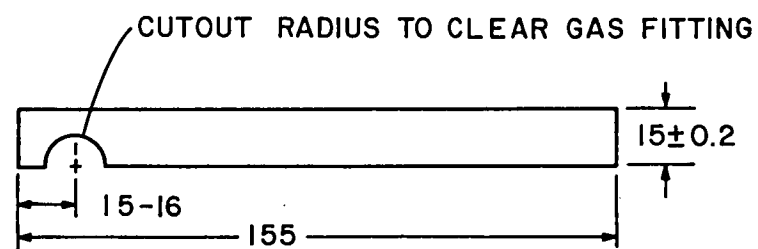
NOTES:

- ① 4 HOLES FOR HOLDING ON COVER, 6 DIA
- ② 12 CLEARANCE HOLES FOR M3x0.5, FOR POLE PIECE CLAMPS
- ③ 3 HOLES, 8.0-8.2 DIA, FOR CATHODE FEEDTHROUGHS
- ④ 3 HOLES, CLEARANCE FOR M5x0.8, FOR CATHODE FEEDTHROUGHS
- ⑤ 6 HOLES, 8.0-8.2 DIA, FOR ANODE FEEDTHROUGHS

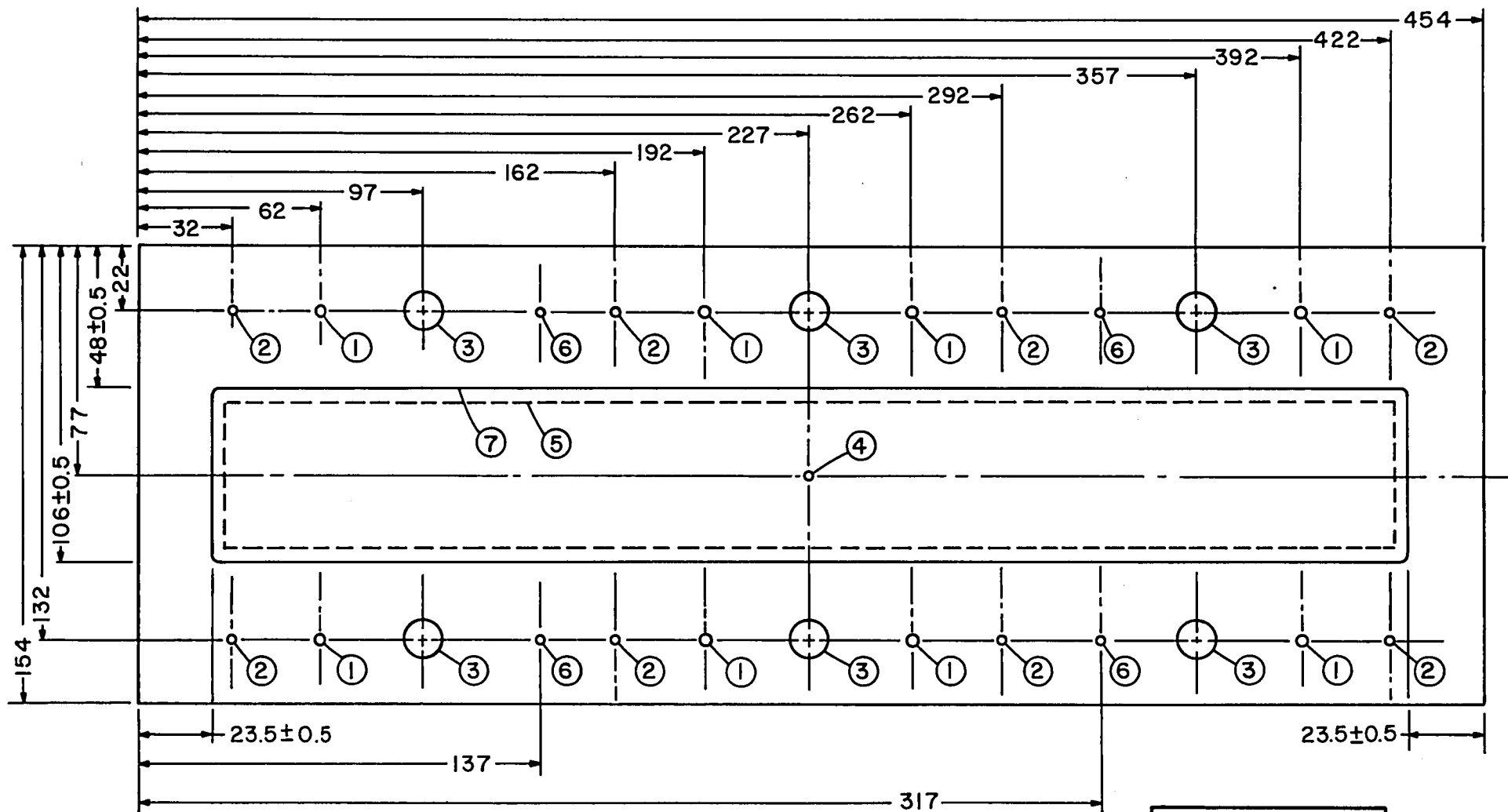
PART NO. 21
CHAMBER COVER
MAT'L: 304 S.S., 1.5 THICK
SCALE: 1/2



PART NO. 22
CHAMBER COVER SIDE
MAT'L: 304 S.S., 1.5 THICK
SCALE: 1/2



PART NO. 23
CHAMBER COVER END
MAT'L : 304 S.S., 1.5 THICK
SCALE : 1/2



FOR NOTES, SEE NEXT PAGE (23)

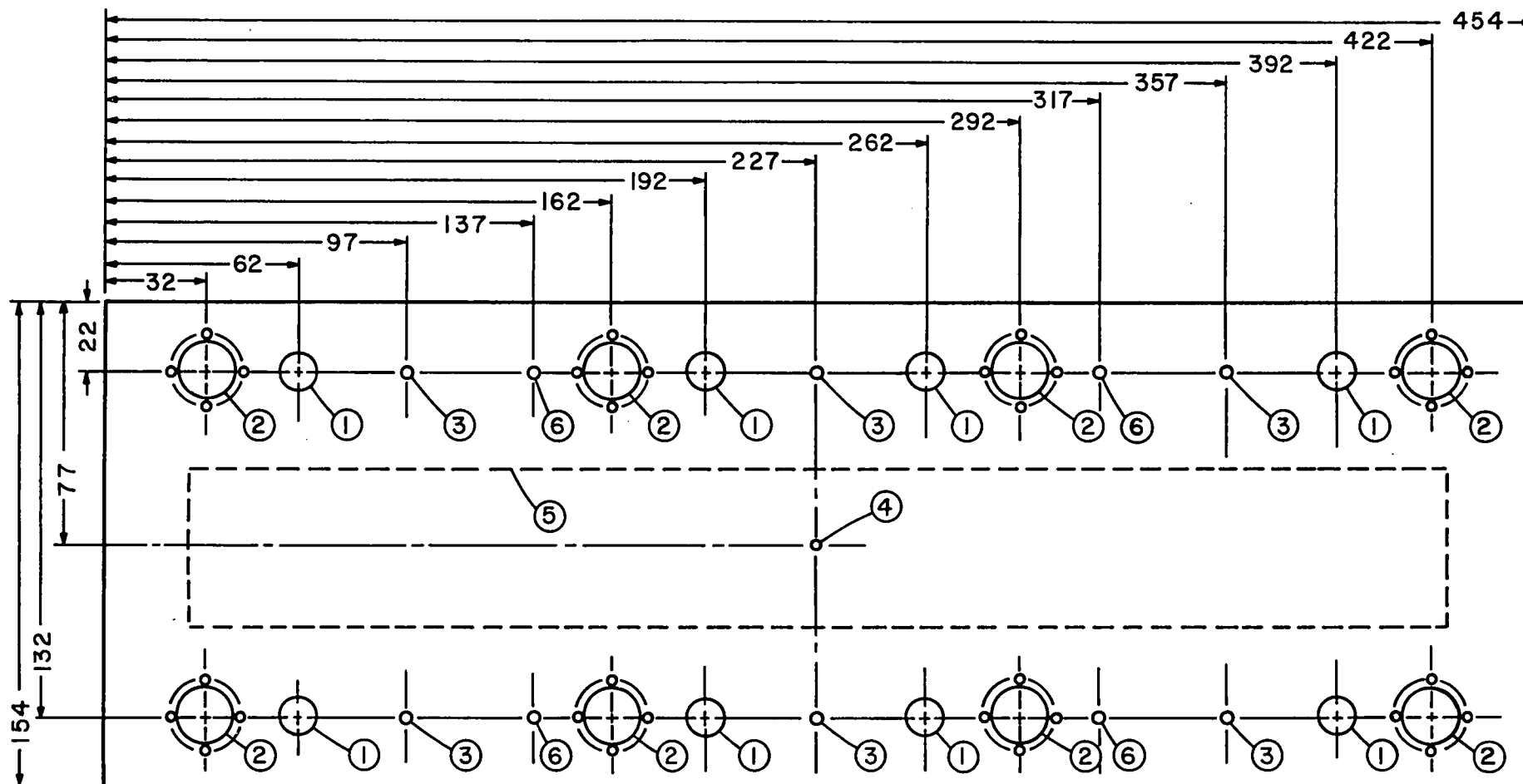
SEE GENERAL NOTES FOR GRAPHITE PARTS (PAGE 28)

PART NO. 24
SCREEN GRID
MAT'L: GRAPHITE
SCALE: 1/2

NOTES:

- ① 8 HOLES, 3.5 DIAMETER, FOR MOUNTING ION OPTICS TO MAIN FRAME.
- ② 8 HOLES, CLEARANCE FOR M3X0.5, FOR SCREEN / ACCELERATOR SUPPORT.
- ③ 6 HOLES, 12 DIAMETER, CLEARANCE FOR ACCELERATOR / DECELERATOR SUPPORT.
- ④ CENTER HOLE OF HOLE ARRAY, 2 DIAMETER , FROM WHICH ARRAY DIMENSIONS ARE REFERENCED.
- ⑤ APPROXIMATE EDGE OF 3669 HOLE ARRAY INDICATED BY DASHED LINE. ALL SCREEN HOLES 2 DIAMETER. DETAILED ARRAY DIMENSIONS SHOWN IN GENERAL NOTES FOR GRAPHITE PARTS (PAGE 28).
- ⑥ 4 HOLES, 2 DIAMETER, FOR GRID ALIGNMENT.
- ⑦ MILL THICKNESS TO 0.5 WITHIN SOLID LINE. MILL AFTER DRILLING HOLE ARRAY, FROM FRONT. (SEE GENERAL NOTES FOR "FRONT" DEFINITION). CORNERS OF MILLED AREA CAN BE RADIUSED, 0-3.5.

PART NO. 24, CONCLUDED



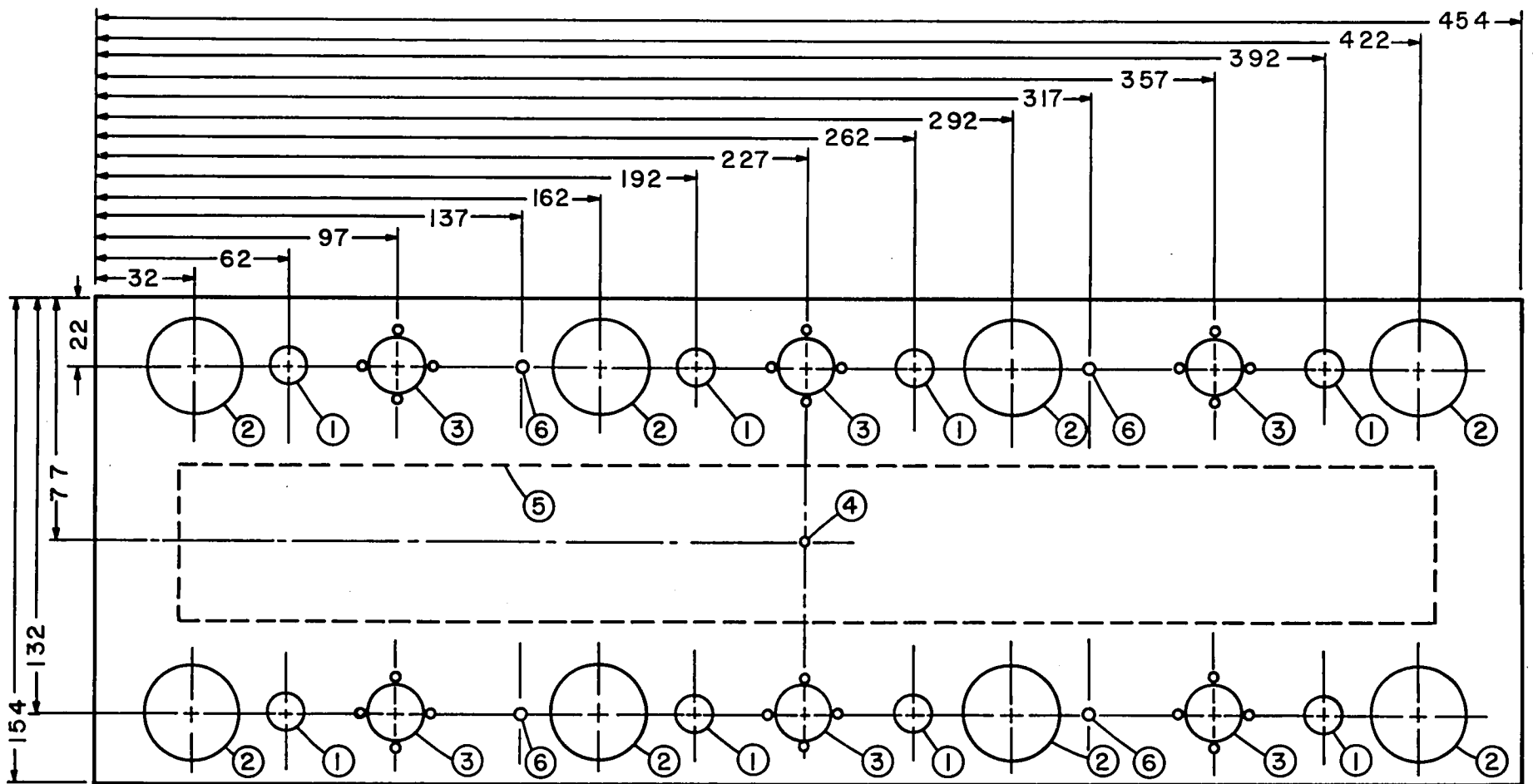
FOR NOTES, SEE NEXT PAGE (25)
SEE GENERAL NOTES FOR GRAPHITE PARTS (PAGE 28)

PART NO. 25
ACCELERATOR GRID
MAT'L: GRAPHITE
SCALE: 1/2

NOTES:

- ① 8 HOLES, 11 DIAMETER, CLEARANCE FOR MOUNTING ION OPTICS TO MAIN FRAME.
- ② 8 HOLES, 17 DIAMETER. 4 HOLES, CLEARANCE FOR M1.6×0.35, EQUALLY SPACED AROUND EACH OF THESE 8 HOLES, ON 22 DIAMETER CONCENTRIC CIRCLE. COUNTERSINK M1.6 CLEARANCE HOLES FOR FLATHEAD SCREWS FROM BACK. (SEE GENERAL NOTES FOR "BACK" DEFINITION.) FOR SCREEN/ACCELERATOR SUPPORT.
- ③ 6 HOLES, CLEARANCE FOR M3×0.5, FOR ACCELERATOR / DECELERATOR SUPPORT.
- ④ CENTER HOLE OF HOLE ARRAY, 1.3 DIAMETER, FROM WHICH ARRAY DIMENSIONS ARE REFERENCED.
- ⑤ APPROXIMATE EDGE OF 3669 HOLE ARRAY INDICATED BY DASHED LINE. ALL ACCELERATOR HOLES 1.3 DIAMETER. DETAILED ARRAY DIMENSIONS SHOWN IN GENERAL NOTES FOR GRAPHITE PARTS (PAGE 28).
- ⑥ 4 HOLES, 2 DIAMETER, FOR GRID ALIGNMENT

PART NO. 25 , CONCLUDED



FOR NOTES, SEE NEXT PAGE (27)

SEE GENERAL NOTES FOR GRAPHITE PARTS (PAGE 28)

PART NO. 26
DECELERATOR GRID
MAT'L: GRAPHITE
SCALE: 1/2

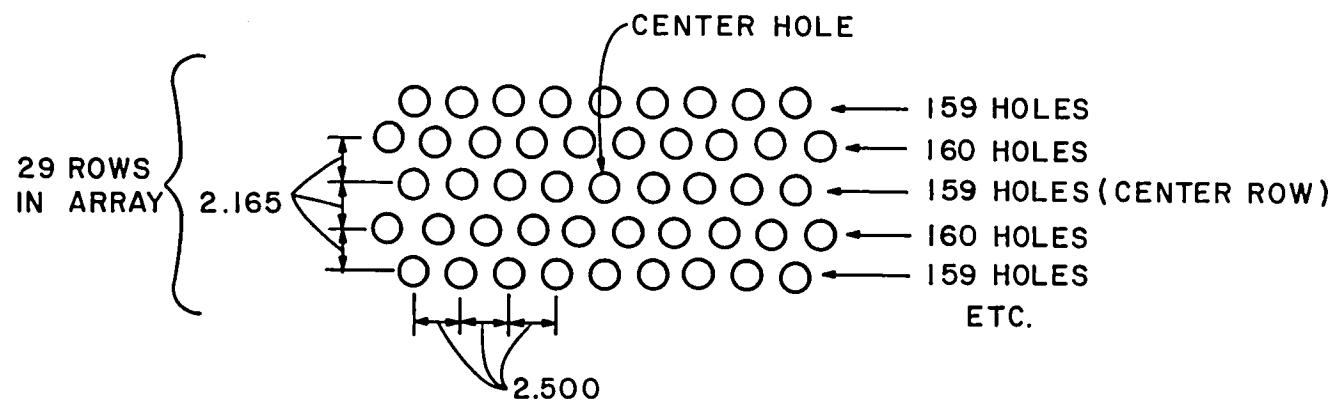
NOTES:

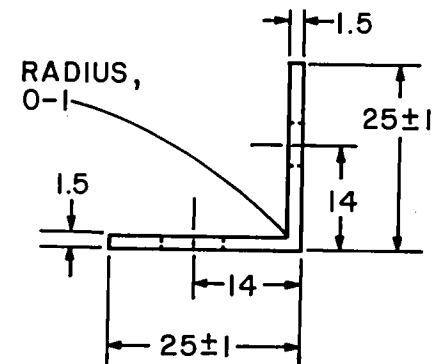
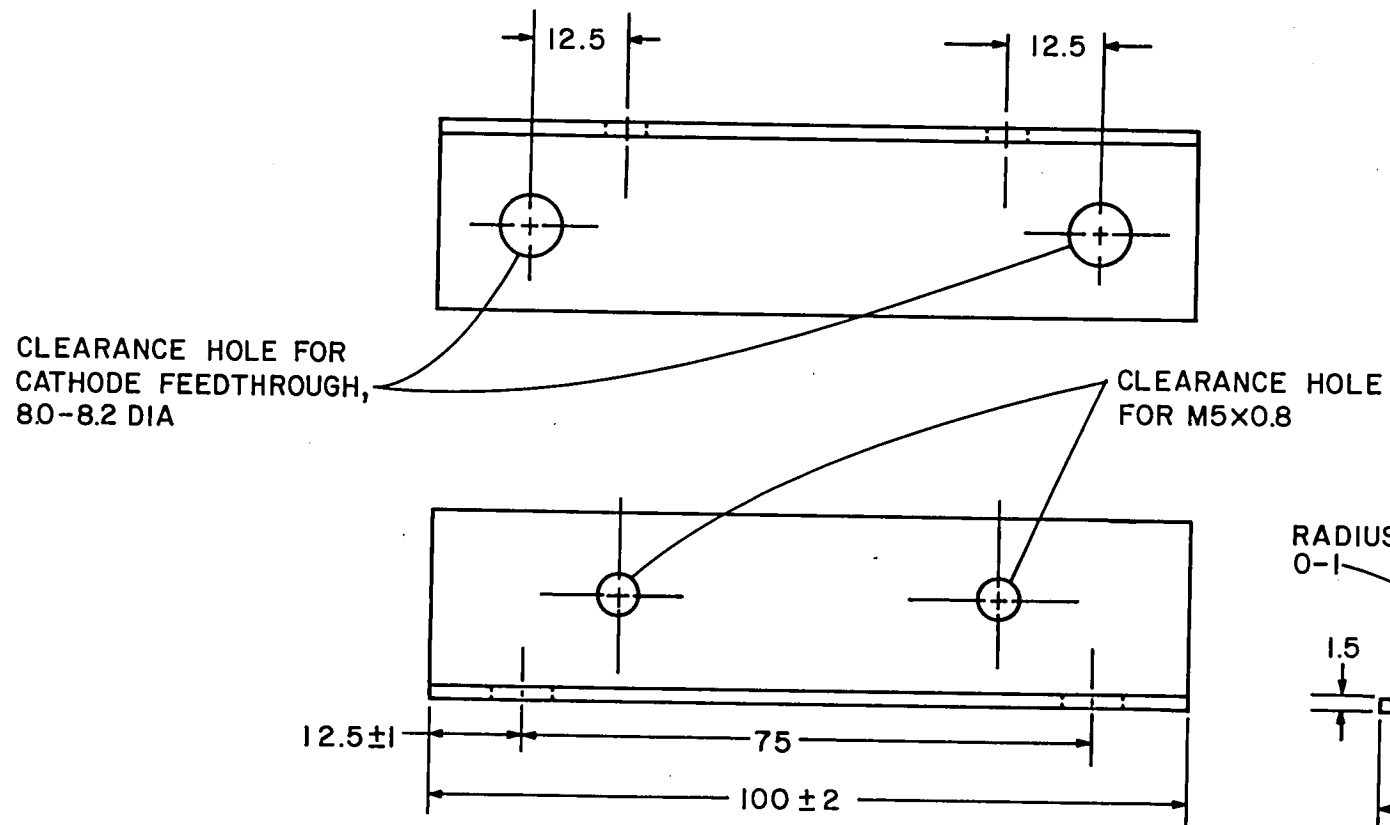
- ① 8 HOLES, 11 DIAMETER, CLEARANCE FOR MOUNTING ION OPTICS TO MAIN FRAME.
- ② 8 HOLES, 29 DIAMETER, CLEARANCE FOR SCREEN / ACCELERATOR SUPPORT
- ③ 6 HOLES, 17 DIAMETER, 4 HOLES, CLEARANCE FOR M1.6 0.35, EQUALLY SPACED AROUND EACH OF THESE 6 HOLES, ON 22 DIAMETER CONCENTRIC CIRCLE. COUNTERSINK M1.6 CLEARANCE HOLES FOR FLATHEAD SCREWS FROM BACK (SEE GENERAL NOTES FOR "BACK" DEFINITION). FOR ACCELERATOR / DECELERATOR SUPPORT.
- ④ CENTER HOLE OF HOLE ARRAY, 1.6 DIAMETER, FROM WHICH ARRAY DIMENSIONS ARE REFERENCED.
- ⑤ APPROXIMATE EDGE OF 3669 HOLE ARRAY INDICATED BY DASHED LINE. ALL DECELERATOR HOLES 1.6 DIAMETER. DETAILED ARRAY DIMENSIONS SHOWN IN GENERAL NOTES FOR GRAPHITE PARTS (PAGE 28).
- ⑥ 4 HOLES, 2 DIAMETER, FOR GRID ALIGNMENT.

PART NO. 26, CONCLUDED

GENERAL NOTES FOR GRAPHITE PARTS :

1. MATERIAL: HIGH DENSITY GRAPHITE, 1 THICK, FLAT WITHIN 1 FOR 154X454 AREA.
2. USE CARBIDE TOOLS TO REDUCE GRAPHITE BREAKAGE
3. FOR MAXIMUM REGISTRATION OF PART NO. 24-26, USE NUMERICALLY CONTROLLED DRILLING AND KEYING MARKS TO ASSURE THE SAME ORIENTATION. "FRONT" AND "BACK" DEFINITION IS ARBITRARY EXCEPT MUST BE CONSISTENT FOR ALL THREE PARTS.
4. 3669 HOLE ARRAY INDICATED BELOW IS ORIENTED THE SAME AS IN THE DRAWINGS FOR PART NOS. 24-26.



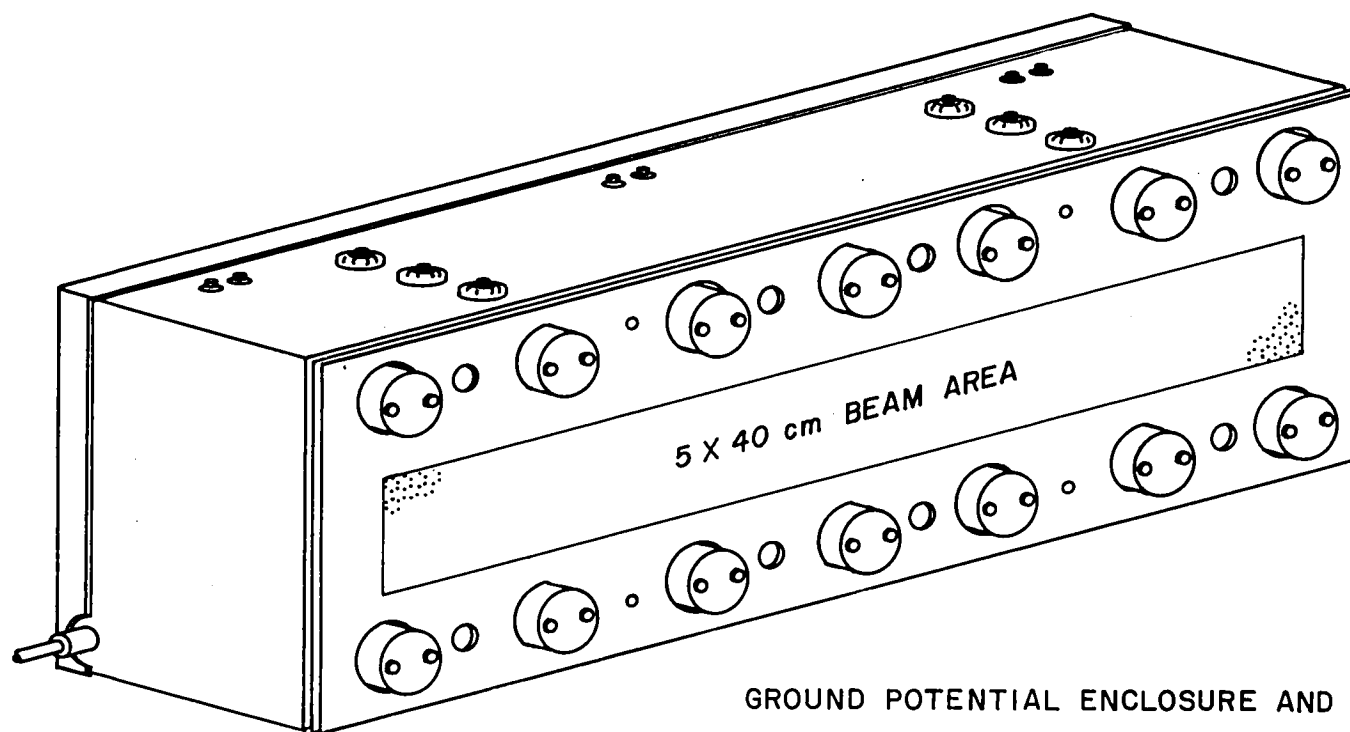


PART NO. 27
SOURCE SUPPORT BRACKET
MAT'L: 304 S.S.
SCALE: FULL SIZE

ASSEMBLY DRAWINGS

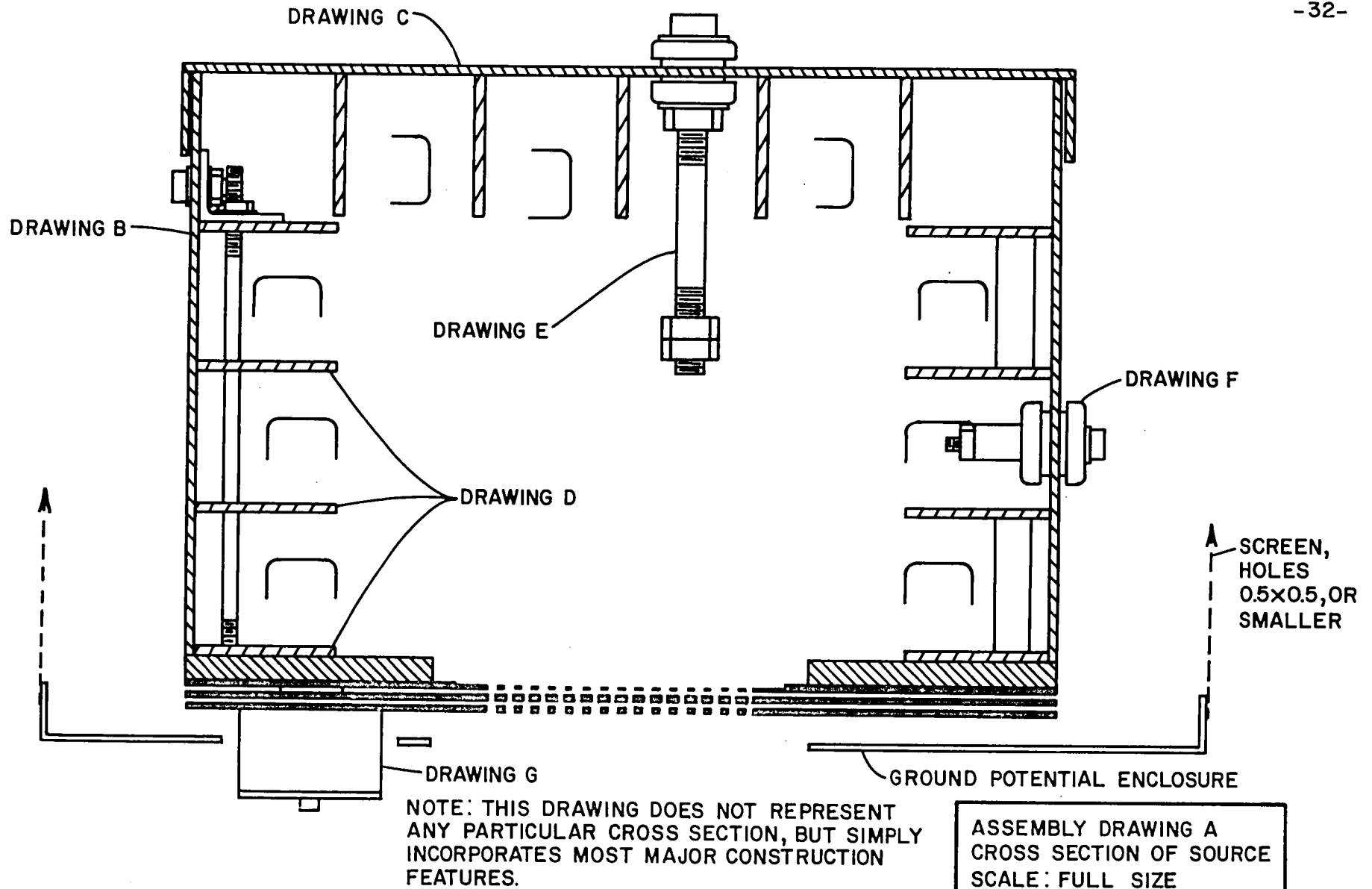
ALL DIMENSIONS IN mm UNLESS OTHERWISE NOTED.

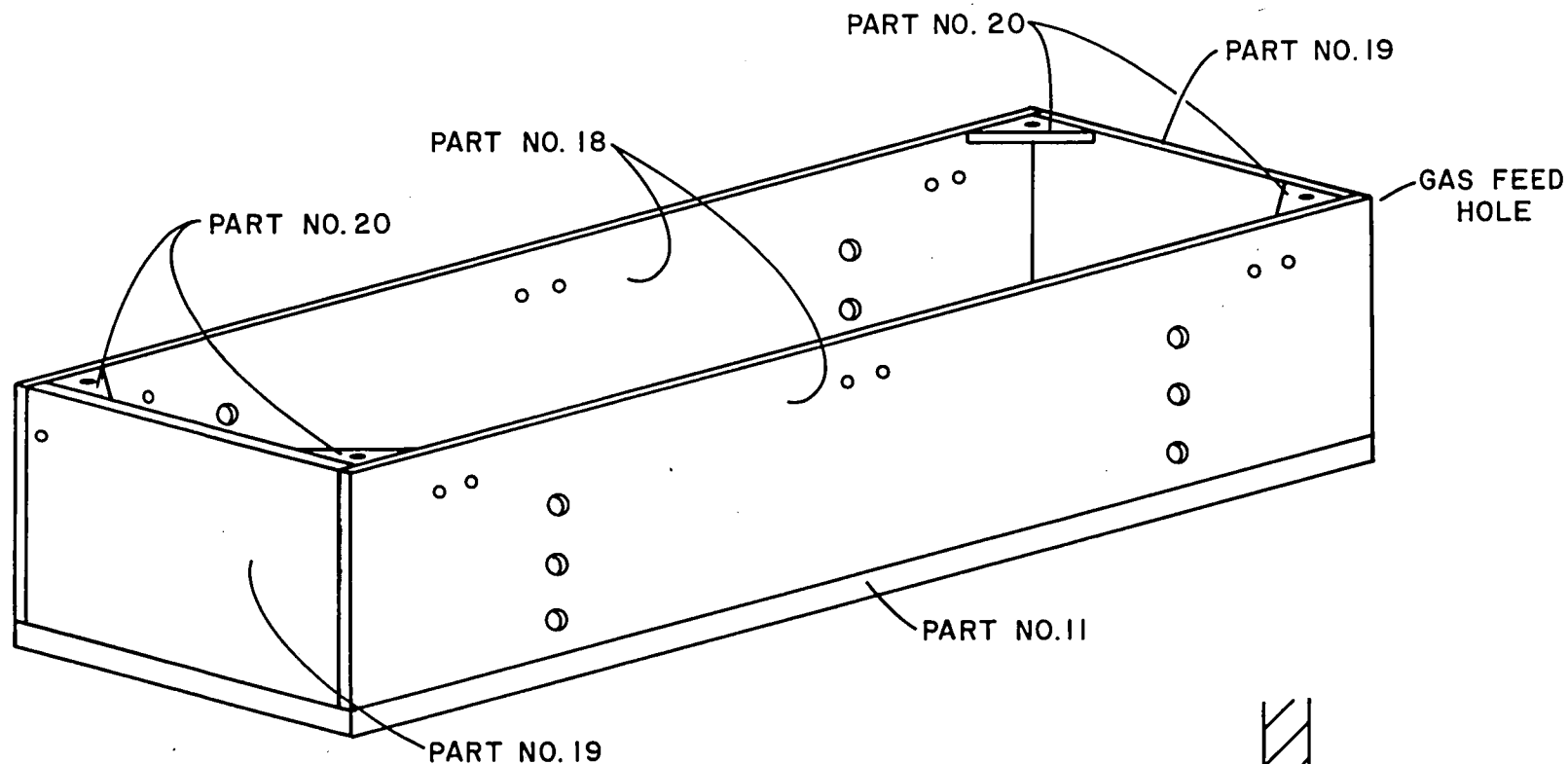
ALL TOLERANCES ± 0.1 mm UNLESS OTHERWISE NOTED.



GROUND POTENTIAL ENCLOSURE AND
SOURCE SUPPORT BRACKETS OMITTED

OVERALL ASSEMBLY
ION SOURCE
NOT TO SCALE



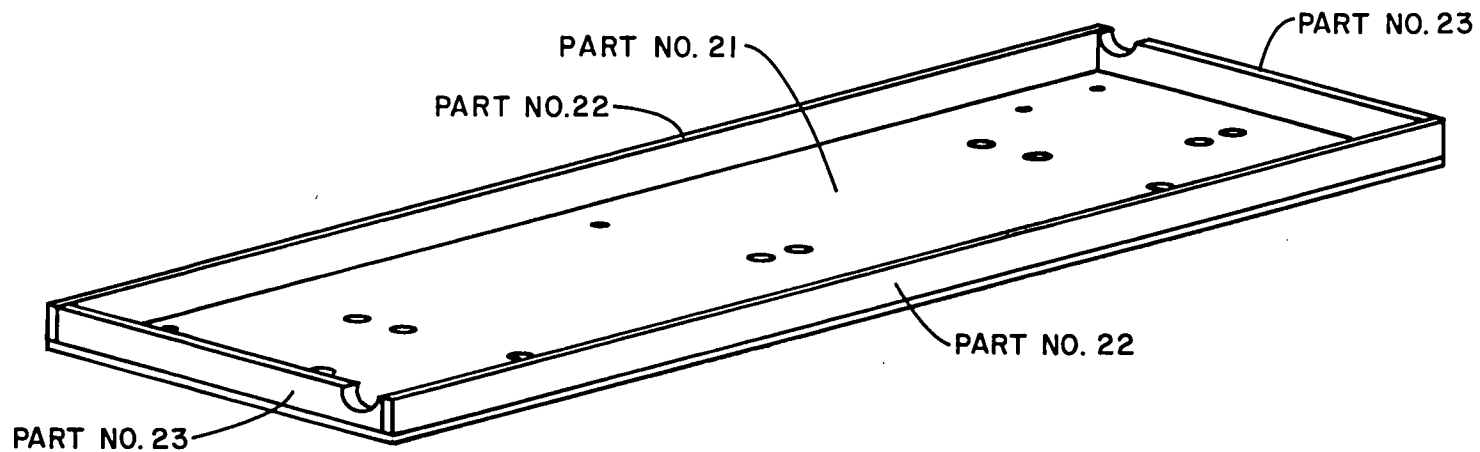


INSTRUCTIONS:

1. JIG WITH ALL JOINT TIGHT AND FLUSH
2. TIG* WELD ALL JOINTS EVERY 20-40 (CONTINUOUS WELD NOT REQUIRED AND MORE LIKELY TO CAUSE WARPING)

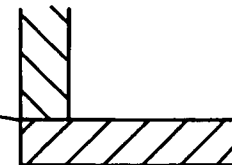
* INERT GAS , TUNGSTEN ARC

ASSEMBLY DRAWING B
MAIN CHAMBER
NOT TO SCALE



INSTRUCTIONS:

1. JIG WITH ALL JOINTS TIGHT AND FLUSH
2. TIG* WELD ALL JOINTS EVERY 20-40
(CONTINUOUS WELD NOT REQUIRED AND
MORE LIKELY TO CAUSE WARPING)

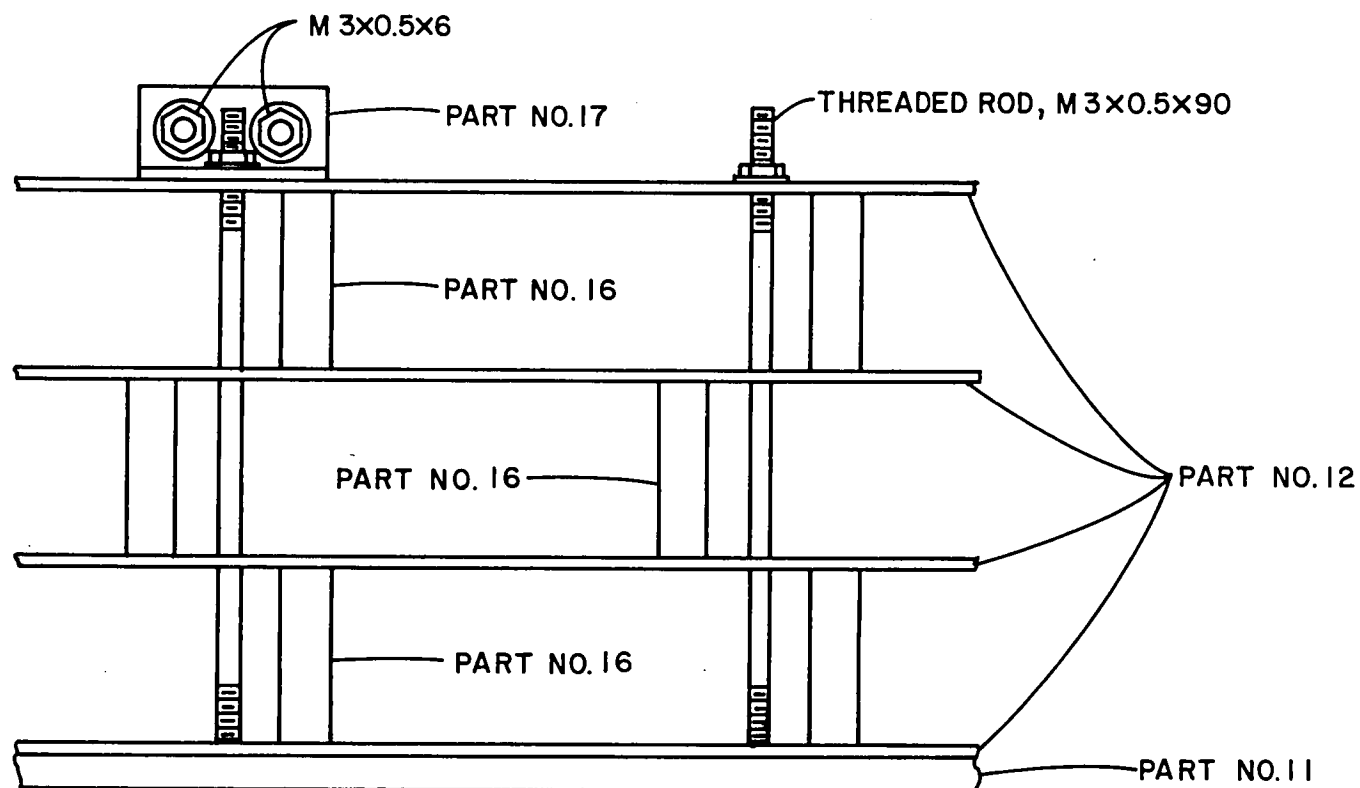


NOTE:

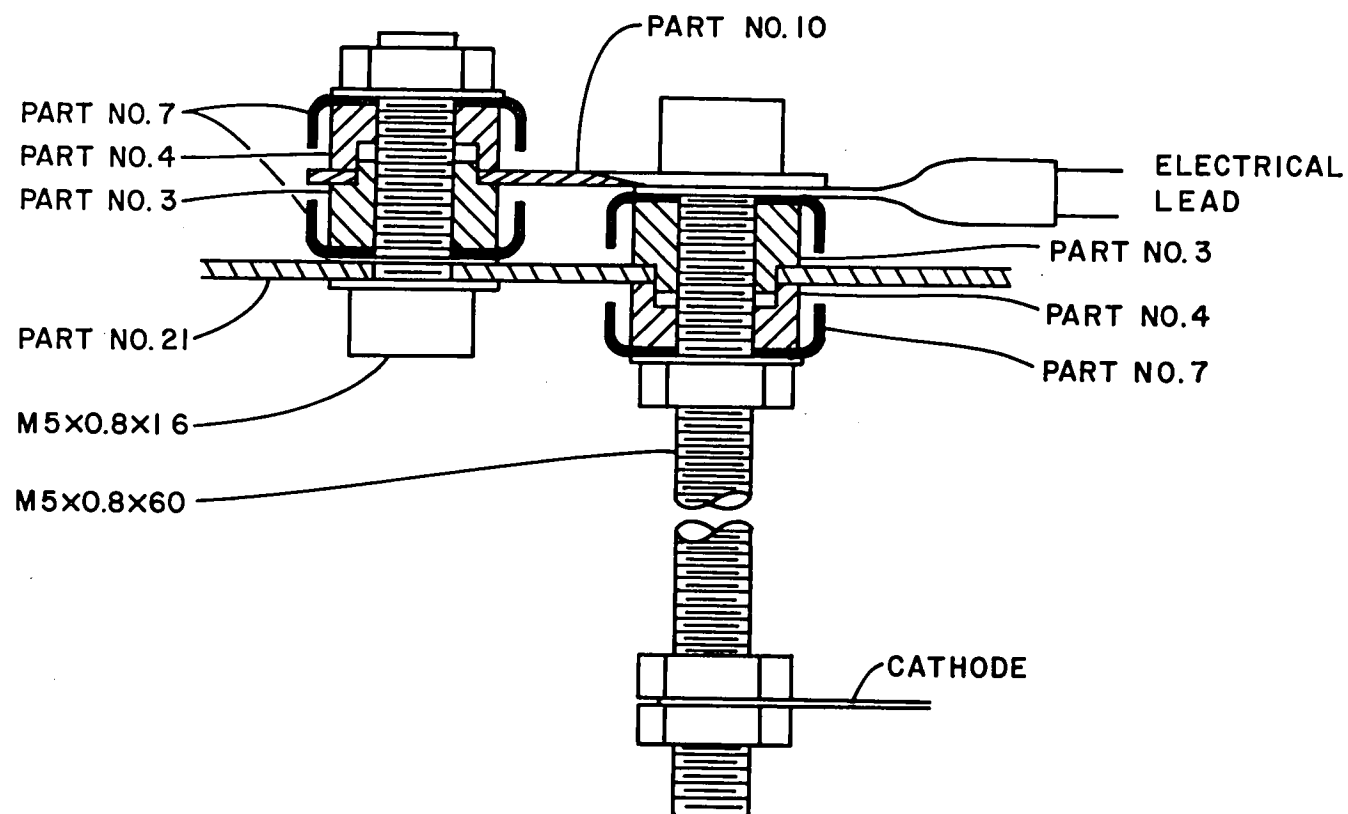
THIS VIEW IS INVERTED RELATIVE TO ASSEMBLY
DRAWING B (PAGE 33).

*INERT GAS TUNGSTEN ARC

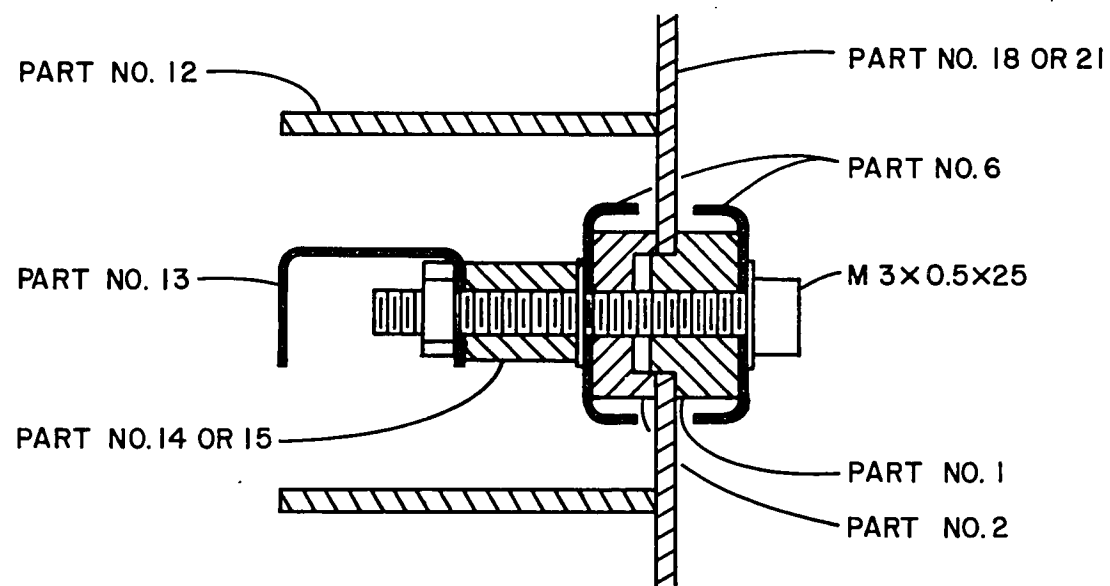
ASSEMBLY DRAWING C
MAIN CHAMBER COVER
NOT TO SCALE



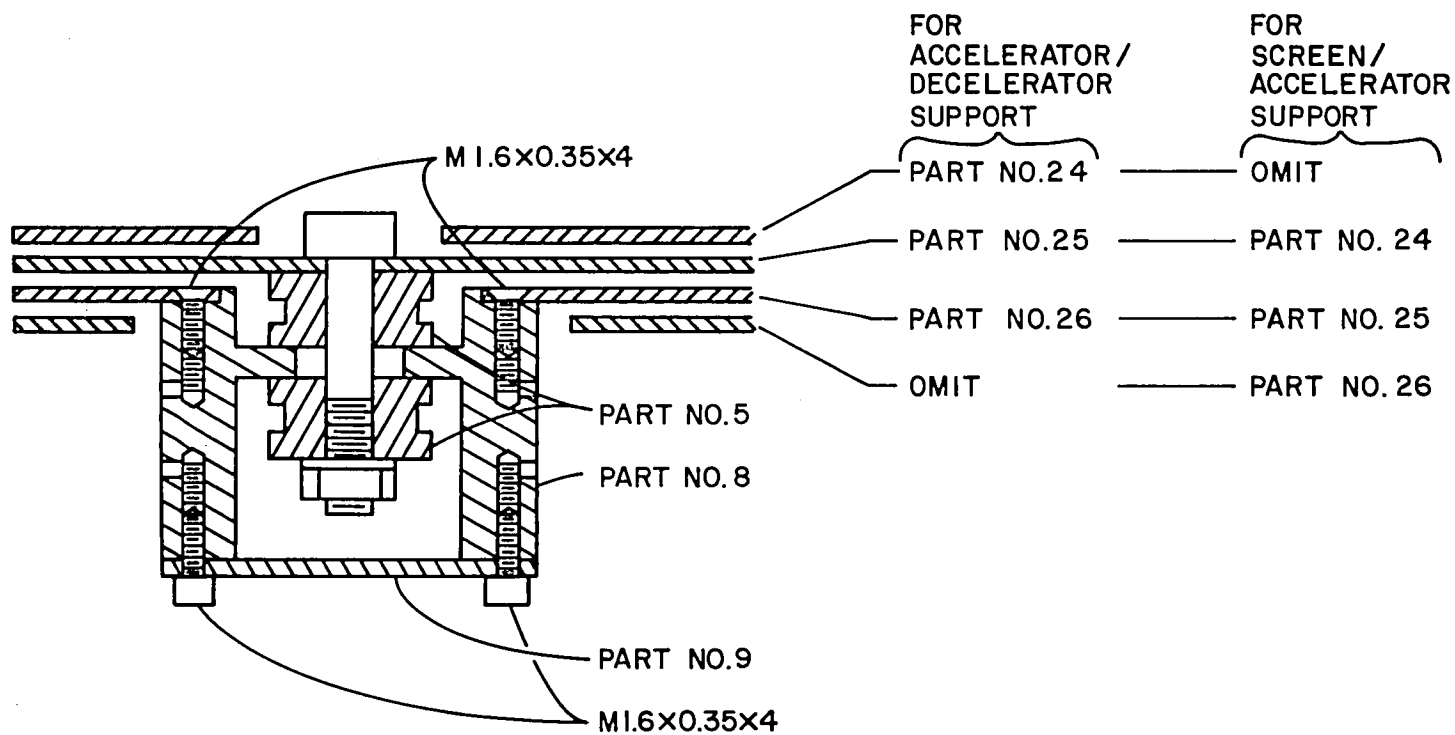
ASSEMBLY DRAWING D
POLE PIECES AND MAGNETS
SCALE: FULL SIZE



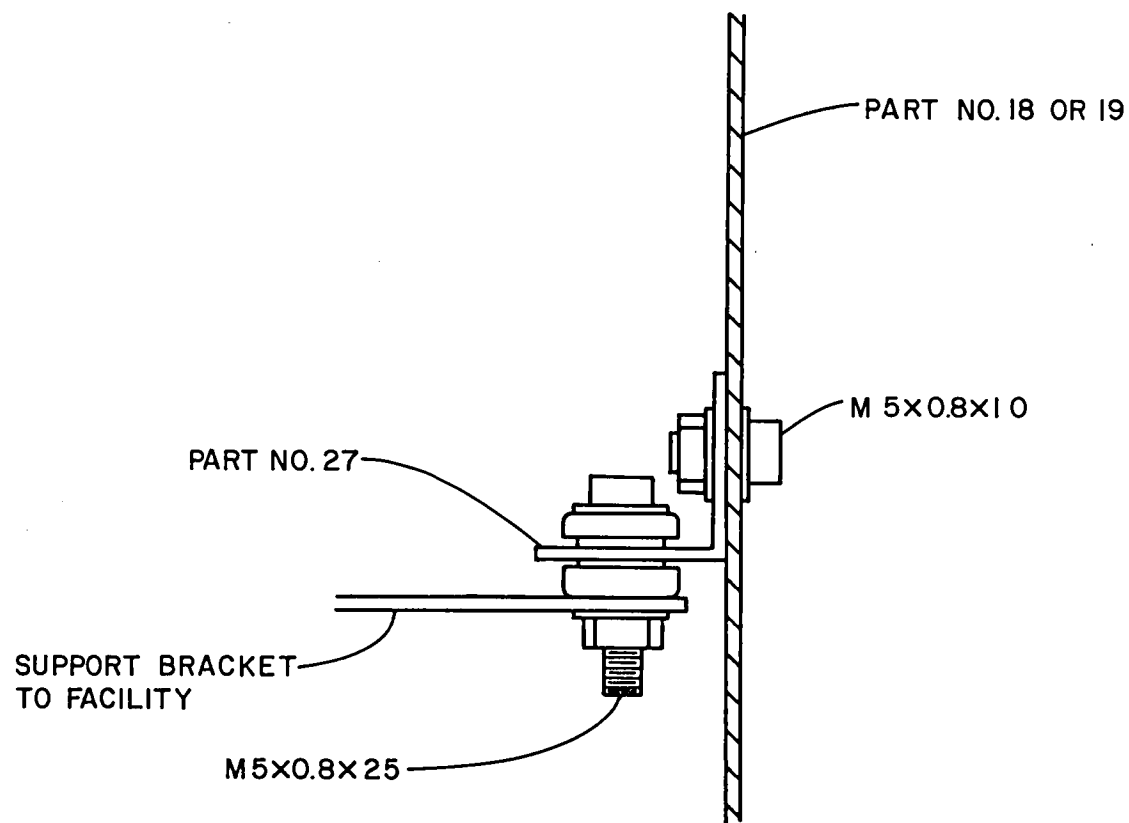
ASSEMBLY DRAWING E
CATHODE SUPPORT
SCALE 2X



ASSEMBLY DRAWING F
ANODE SUPPORT
SCALE: 2X



ASSEMBLY DRAWING G
 ION OPTICS SUPPORT
 SCALE: 2X



ASSEMBLY DRAWING H
SOURCE SUPPORT (TYPICAL)
SCALE: FULL SIZE

PARTS LIST:

PART NO.	NO. REQ. / UNIT
1	18
2	18
3	10
4	10
5	14
6	36
7	20
8	14
9	14
10	3
11	1
12	13
13	9
14	8
15	10
16	50
17	12
18	2
19	2
20	4
21	1
22	2
23	2
24	1
25	1
26	1
27	2

THREADED PARTS, 18-8 OR 304 S.S.

THREAD	LENGTH	DESCRIPTION	NO. REQ.	WHERE USED
M 1.6x0.35	4	SCREW, FH*	56	ION OPTICS SUPPORT
" "	4	" , SH**	28	" " "
M 3x0.5	4	SCREW, SH	8	ION OPTICS MOUNTING
" "	6	" "	24	POLE PIECE CLAMPS
" "	16	" "	14	ION OPTICS SUPPORT
" "	25	" "	18	ANODES
" "	90	THREADED ROD	10	POLE PIECE ASSEMBLY
" "	120	" "	5	" " "
" "	—	NUTS	76	—
" "	—	WASHERS, ASSORTED	~100	—
M 5x0.8	6	SCREW, SH	4	COVER
" "	16	" "	7	CATHODE, SOURCE SUPPORT
" "	25	" "	4	SOURCE SUPPORT
" "	60	" "	3	CATHODE
" "	—	NUTS	44	—
" "	—	WASHERS	~30	—

* FLAT HEAD, PREFERABLY HEX DRIVE

** SOCKET HEAD

MATERIALS LIST:

MATERIAL	NO. REQ.	DESCRIPTION	PART NO.
ALUMINUM OXIDE	70	96 %, OR MORE Al_2O_3 , ≤ 11 DIA, 6 LONG	1-5
ALNICO V	50	6.3 DIA, 25.4 LONG, MAGNETIZED	16
GRAPHITE	3	HIGH DENSITY, 1 THICK, 154X454 RECT	24-26
LOW CARBON STEEL OR 400 SER. S.S.	13	1.5 THICK, 25X450	12
18-8 OR 304 S.S.	—	SEE THREADED PARTS LIST	—
304 S.S.	56	0.25 THICK BLANKS, ≤ 30 DIA.	6-7
	9	0.5 THICK, 25X440 RECT	13
	14	1 THICK, 25 DIA.	9
	3	" " 15X35 RECT	10
	12	" " 25X25 RECT	17
	2	1.5 THICK, 103X454 RECT	18
	2	" " 103X151 RECT	19
	1	" " 158X458 RECT	21
	2	" " 15X458 RECT	22
	2	" " 15X155 RECT	23
	2	" " 50X100 RECT	27
	4	4.0-4.5 THICK, 23X23 RT TRIANGLES	20
	1	" " 154X454 RECT, 304L PREFERRED	11
	8	6 DIA, 5.5 LONG	14
	10	" " 6.5 LONG	15
	14	25 DIA, 17 LONG	8
TANTALUM OR TUNGSTEN	—	WIRE, 0.75 DIA, MINIMUM ORDER	CATHODES
	—	" 0.25 DIA " "	NEUTRALIZERS

ASSEMBLY INSTRUCTIONS

General

All dimensions are in mm. Numbers shown in parentheses are Part Numbers. Except for Pole Pieces (12) and Magnets (16), all parts should be essentially nonmagnetic. The small magnetic response that can be produced in 304 or 18-18 stainless steel by cold-working should be ignored. Placement of washers is omitted in these instructions. Use Assembly Drawings and normal practice for such placement.

Main Chamber and Main Chamber Cover

Assembly Drawings B and C should be used as a guide in the assembly of the Main Chamber and the Main Chamber Cover. For correct fit of these parts, all joints should be tight and flush as indicated in these assembly drawings. Small openings at the joints (<0.3) should not affect operation, if the mechanical fit is satisfactory. Corners and edges should be smoothed to permit Main Chamber Cover to go over Main Chamber with no interference.

Ion Optics Assembly

As a general comment, the graphite sheets used for the Ion Optics are relatively fragile, and need more care in handling than metal parts. Attach 14 Ion Optics Supports (8) to Accelerator Grid (25) and Decelerator Grid (26) using flat head M1.6 \times 0.35 \times 4 screws. Invert Main Chamber with Main Frame (11) facing up. Place screen grid (24) with milled side

down on Main Frame. Place 8 Ion Optics Insulators (5) on holes of Screen Grid used for Screen/Accelerator support. (See notes for Screen Grid (24) to identify those holes.) Place Accelerator Grid (25), with Ion Optics Supports up, on top of Screen Grid. Place 8 more Ion Optics Insulators on top of Ion Optics Supports. Use 4 rods or drill shanks, 2 diameter, to align Screen Grid and Accelerator Grid, using jiggling holes in those grids and in the Main Frame for this purpose. Using M3 \times 0.5 \times 16 screws and M3 \times 0.5 nuts, clamp Accelerator Grid to Screen Grid. With M1.6 \times 0.35 \times 4 socket head screws, attach 8 Ion Optics Support Covers (9) to Ion Optics Supports on Accelerator Grid. Ion Optics Supports and adjacent hardware should, at this time, resemble Screen/Accelerator Support portion of Assembly Drawing G.

Place 6 more Ion Optics Insulators on holes of Accelerator Grid used for Accelerator/Decelerator support. (See notes for Accelerator Grid (25) to identify those holes.) Place Decelerator Grid, with Ion Optics Supports up, on top of Accelerator Grid. Place 6 more Ion Optics Insulators on top of uncovered Ion Optics Supports. Again use 4 rods or drill shanks, 2 diameter, to align Accelerator Grid and Decelerator Grid. Using M3 \times 0.5 \times 16 screws and M3 \times 0.5 nuts, clamp Decelerator Grid to Accelerator Grid. With M1.6 \times 0.35 \times 4 socket head screws, attach 6 Ion Optics Support Covers to uncovered Ion Optics supports. At this point, check with Accelerator/Decelerator Support portion of Assembly Drawing G.

Remove assembled Ion Optics and place to one side. Ion Optics can be re-aligned after Magnetic Pole Pieces (12) are assembled within Main Chamber,

but a slightly different technique will be required because the heads of the M3×0.5×16 screws will be covered. Either a separate jig with 4 holes, 2 diameter, should be fabricated, or the threaded ends of the M3×0.5×16 screws should be slotted so they can be kept from rotating with a screwdriver.

Magnetic Pole Piece and Magnet Assembly

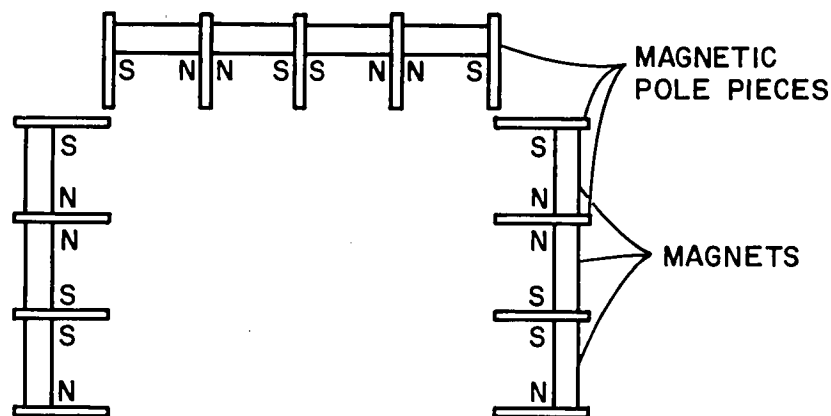
Assemble 8 Magnetic Pole Pieces (12) within Main Chamber. (See Assembly Drawings A and D.) Using 5 threaded rods, M3×0.5×90, on each side, assemble Magnetic Pole Pieces with 5 Magnets (16) between each adjacent pair of Magnetic Pole Pieces. (See following section on Magnetic Polarity and Field Strength before assembling with Magnets.) Threaded rods should not extend beyond outside surface of Main Frame (11). Hold assembly in place with M3×0.5 nuts on all rods. Do not tighten nuts excessively, which will bend the Magnetic Pole Pieces. Remove one nut at a time from threaded rods to install each of a total of 6 Pole Piece Brackets (17), using additional M3×0.5×6 screws and M3×0.5 nuts.

Assemble 5 Magnetic Pole Pieces on Main Chamber Cover. (See Assembly Drawing A.) Using 5 threaded rods M3×0.5×120, assemble Magnetic Pole pieces with 5 Magnets between each adjacent pair of Magnetic Pole pieces. (Again, see following section on Magnetic Polarity and Field Strength before assembling with Magnets.) Threaded rods should extend nearly equally on both sides of the outside Magnetic Pole Pieces. Hold assembly of Magnetic Pole Pieces and Magnets together with M3×0.5 nuts on both ends of

all 5 threaded rods. Remove one nut at a time from threaded rods to install each of a total of 6 Pole Piece Brackets, using additional M3×0.5×6 screws and M3×0.5 nuts.

Magnetic Polarity and Field Strength

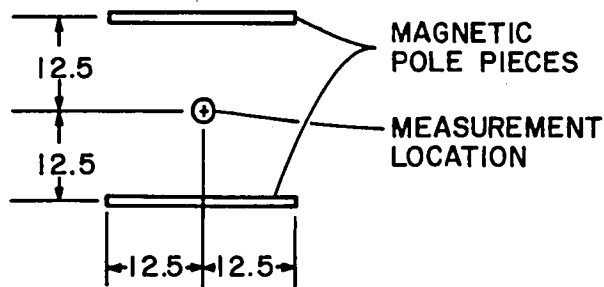
All 5 Magnets (16) between a pair of Magnetic Pole Pieces (12) should have the same polarity. The direction of the polarity for a particular set of 5 Magnets is not important. It is important that adjacent sets of 5 Magnets have opposite polarity, as indicated in the sketch below. Magnets should



give acceptable field strength when delivered from the manufacturer in the magnetized state. But a number of problems can arise. Various manufacturers may supply magnets of different strengths.

Also, careless handling after delivery can result in large changes in magnetization, usually decreases. Finally, one or more magnets of a set of 5 may be assembled in a reversed orientation relative to the others. For these reasons, checks must be made on field strength after assembly. A more precise check is described in the later section on Anode Installation. A simpler check suitable for routine assembly is described below.

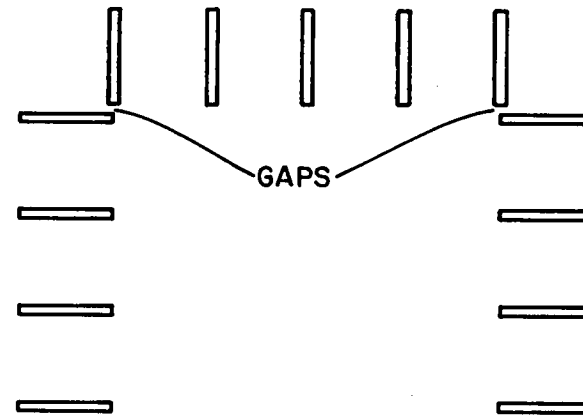
The magnetic field strength should be measured at a point midway between a pair of Magnetic Pole Pieces, as indicated in the sketch below. This



measurement should be well away from the ends of the Magnetic Pole Pieces, but is otherwise not extremely sensitive to location, so that locating within ± 1 in directions shown should be adequate for the measurement. The recommended field strength for this location is 70 ± 10 Gauss. Magnets should be remagnetized, demagnetized, or exchanged in positions to achieve measurements within this range.

Clearance for Gas Flow

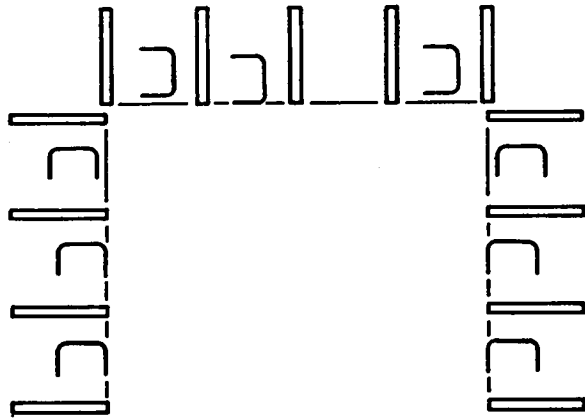
With Magnetic Pole Pieces (12) installed, the Main Chamber Cover should be attached to the Main Chamber, using 4 M5 \times 0.8 \times 6 screws. There should be gaps between the two pairs of corner Magnetic Pole Pieces, as indicated in the sketch below. The



exact values of these gaps are not important. They should, however, be uniform, preferably within $\pm 20\%$ (both from one gap to the other and along a single gap). It may be necessary to place shims under the ends of some Magnets or slightly bend some of the Magnetic Pole Pieces to achieve this uniformity. It is important that any rough edges between the Main Chamber Cover and the Main Chamber be removed before checking for gap uniformity.

Anode Installation

Using Anode Feedthroughs (1) and (2), Anode Sputter Shields (6), Anode Spacers (4) of (5), M3×0.5×25 screws, and M3×0.5 nuts, the Anodes (13) should be installed in the Main Chamber Cover and Main Chamber, as indicated in Assembly Drawings A and F. It should be kept in mind that excessive tightening of the nuts and screws can break the Anode Feedthroughs. The Anode position relative to adjacent Magnetic Pole Pieces (12) depends on the Anode location in the Main Chamber. The inside edge of most Anodes should be flush, ± 0.5 , with the inside edges of adjacent Magnetic Pole Pieces, as indicated in the sketch below. The corner anodes



should be recessed, 2 ± 0.5 , relative to the inside edges of adjacent Magnetic Pole Pieces, as also indicated in the sketch. The Short Anode Spacers

(14) should be used for corner Anodes, while the Long Anode Spacers (15) should be used with other Anodes. The use of various washers will probably also be required for correct Anode placement.

The control of electron diffusion to the anodes is accomplished by the integral of magnetic field over the distance from the anode to the center of the discharge chamber $\int \vec{B} \times d\vec{X}$, with most of this integral close to the anodes. The recessed locations of the corner Anodes are required to give the same magnetic field integral (see NASA CR-159877 for discussion of this integral) for these Anodes as for the others, despite the corner magnetic field interference. This integral can be obtained by multiple magnetic field measurements and graphical integration, and should be 54 ± 10 Gauss-cm ($54 \pm 10 \times 10^{-6}$ T-m) for the electrical performance to match that in CR-159877. If the mean magnetic field integral is lower, the discharge losses will be higher for otherwise similar operating conditions. If the mean integral is higher, the discharge will be hard to start and may require high discharge voltages to maintain. If there is a discrepancy between a desired integral value and a desired mid-point field strength (see preceding section on Magnetic Polarity and Field Strength), the integral value should take precedence.

Cathode Installation

The 3 Torque Plates (10) should be silver soldered or brazed to the heads of 3 M5×0.8×60 screws. The Cathode Supports should then be assembled to the inside of the Main Chamber Cover using Cathode Feedthroughs (3) and (4), Cathode

Sputter Shields (7), M5×0.8×16 screws and M5×0.8 nuts. (See Assembly Drawing E.) Again, excessive tightening of nuts can break Feedthroughs.

Mounting Ion Optics

Use 8 screws, M3×0.5×4, to mount assembled Ion Optics to Main Frame (11) through mounting holes. (See notes on (24), (25), and (26) to determine which are mounting holes.) These screws should be finger tight to permit relative thermal expansion between the Main Frame and the Screen Grid.

The M1.6×0.35×4 socket head screws on the Ion Optics Support Covers (9) can be used for electrical contact with the Accelerator Grid (25) and the Decelerator Grid (26). Alternatively, separate attachments can be made to these grids.

Ground Screen or Enclosure

All positive-potential surfaces on the ion source must be covered by a grounded enclosure (often called a ground screen). The enclosure can be a solid surface or a fine-meshed screen (or perforated sheet). Some fine-meshed screen area may be desirable for rapid outgassing, rather than forcing all the outgassing to pass through gaps near, or in, the Ion Optics. This grounded enclosure serves to isolate the positive-potential surfaces from the charge-exchange plasma that is generated by beam ions passing through the neutral background gas. The approximate location of the grounded enclosure near the ion beam is indicated in Assembly Drawing A.

The grounded enclosure should be cut back from the beam edge to avoid contamination by high-angle beam ions striking the edge of the enclosure. It is sufficiently conservative to assume that all beam ions are within a 45° half-angle from mean beam direction.

If holes in the grounded enclosure are provided for the Ion Optics Supports (8), the exposed surfaces of the Screen/Accelerator Supports will increase the measured current to the Accelerator Grid (25), but will not otherwise affect operation. If desired, small cups in the enclosure can be used to cover these negative-potential surfaces, and reduce the current to the Accelerator Grid.

Detailed drawings of the grounded enclosure are not shown, because they would be dependent on the vacuum facility used.

Ion Source Support

The support of the ion source is also facility dependent, so the exact location of attachment is not shown. A sample Source Support Bracket (27) is indicated in the FABRICATION DRAWINGS section. Support would be adequate with one such Bracket on each end of the ion source. (See Assembly Drawing H.) The location should, of course, be such that internal hardware does not conflict. The parts count (see PARTS LIST section) is consistent with the use of two such Brackets, together with the required additional Cathode Feedthroughs (3) and (4), Cathode Sputter Shields (7), and M5×0.8 screws and nuts.

The Brackets could also be attached to the Main Chamber at any other location that does not cause interference. More than 2 Brackets may be required for other locations, requiring an adjustment in parts count.

Main Cathode

A main cathode of 0.75 diameter tantalum provides adequate emission with a heating current of 30 A at a little over 20 V. This current is for one long cathode the full length of the source. If the center Cathode Support is used to connect two half-length cathode segments in parallel, the current would be doubled and the voltage halved.

Tungsten, 0.75 diameter, can also be used for the main cathode, with a somewhat increased current and a decreased voltage. Tungsten would also creep less than tantalum at operating temperature, so that less sag would be observed after operation.

The preferred method for cathode replacement is to remove the 4 screws, M5×0.8×6, that secure the Main Chamber Cover to the Main Chamber. With the Cover lifted, the cathode can easily be replaced. If the cover is to be removed to a workbench for this replacement, quick disconnects should be provided in the electrical leads to the Cover.

The cathode can also be replaced by removing the Ion Optics from the source. This approach involves both more work and more risk of damaging the Ion Optics.

Neutralizer

No Neutralizer is shown. Two well separated (>10 apart) tantalum-wire emitters, each 0.25 diameter, across the small beam dimension should provide adequate electron emission. Alternatively, a single oblique emitter with twice the immersion length in the ion beam should also be satisfactory. A single 0.25 diameter neutralizer of tantalum requires about 5 A heating current and 1 V/cm of total length. As with the main cathode, tungsten can be used to replace the tantalum with an increase in current and decrease in voltage.

The neutralizer supports are not shown, but may be similar to the main Cathode Supports. They may be attached to the grounded enclosure or some part of the surrounding vacuum facility. The parts count includes no contribution from the neutralizer.

